EMERGENCY SURGERY

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DEDICATION

In humble sincerity this volume is dedicated to that army of American surgeons who have devoted their talents not only to the saving of human life, but as a contribution to our democratic American Way of Life that galaxy of unhonored servants of mankind, who despite the growing materialism of our age have plied their labors in consonance with the law of God, knowing—

"That very law which moulds a tear
And bids it trickle from its source
That law preserves the earth a sphere
And guides the planets in their course"

Foreword

Though in certain respects surgical technic has become standardized, yet at any time even during the performance of what may be regarded as a routine operation, an emergency may arise and a difficult problem demand immediate solution The surgeon is judged, and rightly judged by the way in which he deals with such calls upon his skill and judgment. If he becomes flustered gives contradictory orders has no definite plan to deal with the crisis, and generally seems at a loss how to proceed it will be clear to everyone that there is a defect of training of temperament, or of both. If on the other hand, he remains calm retains a steady hand shows fertility of resource and successfully overcomes the difficulty we acknowledge the master surgeon.

Some men have greater natural self possession than others and with increasing experience everyone becomes more resourceful, but no surgeon, however experienced, is likely to have met every possible emergency and the young surgeon with his limited opportunities, may have encountered but few There is therefore, something to be gained by all surgeons in having available for ready reference some guide book which gives the relevant information concerning all the likely surgical emergencies. To be forewarned is to be forearmed Knowledge of how the expert has solved a problem should always help in dealing with a similar difficulty To provide this knowledge is the purpose of this book which covers a wide field, and in which every effort has been made to furnish the best and most up-to-date information. May its purpose be fulfilled.

V Zachary Cope

London, England

Preface

THE problems involved in the emergency case are always a challenge to the alertness preparedness and acumen of every doctor of medicine There are among our profession many whose contact with accidental injury is a regular part of their daily routine These men who are especially *trained by their predecessors* or by their own vast experience or by the dint of constant mental effort, meet these emergencies with a knowledge that leads to good treatment and consequently desired results.

On the other hand countless physicians are held responsible in the case of an emergency regardless of their specialty or their lack of interest in this type of practice. None of us can be excused from duty when a disaster comes and our services are needed There have been directives of a broad nature already issued, and some efforts have been made to educate lay workers as well as physicians to act with some clarity under these circumstances World War II manuals are available and although chiefly concerned with the military problems of encampment and battle, are still of value Doubtless these will be expanded and new subjects will be covered in due time.

There is not however a single compact volume that covers the emergency situations that occur daily and those that can be anticipated under our present uncertain and precarious state of international affairs. In this new book, edited by Dr Ficarra we have a most important directive to guide every physician, when the emergency arises The first treatment, even to the position of the injured best *suited for* transportation is the one that, when correctly carried out, saves a life

This book should be the bible of every emergency ward surgeon, and the handy reference guide for every doctor's office. Here will be found tested and tried methods of procedure made available to all from the vast experience of experts in this important field of surgery

Boston Mass. ARTHUR W ALLEN M.D

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Introduction

ONE of America s greatest contributions to the advancement of surgical knowledge is the voluminous literature written on the various aspects of surgery The dignified surgical journals and the masterfully composed text books which have appeared during the past decades attest to the American genius for stimulating great efforts in surgery which aid humanity by eradicating disease.

Every article published and every book written do not always contain new found information or a great discovery Nevertheless they bring to the attention of men of medicine and surgery certain facts and gifts of knowledge which have been found useful in alleviating the pains of a suffering humanity as well as curtailing the scourge of disease.

This book on EMERGENCY SURGERY it is hoped will be accepted as a text of this type namely that it will contain information that will assist in serving humanity To quote Sir William Osler our purpose is "to track to their sources the causes of diseases to correlate the vast stores of knowledge that they may be *quickly* available for the prevention and cure of diseases—these are our ambitions."

The authors who have created this book should be complimented and congratulated. Each has performed his task well and their presentation of the various subjects is a written testimony and tribute to their talents The material presented encompasses the management of emergencies encountered in the various regions of the human body and the human body as a psychosomatic entity Emphasis has been placed upon the treatment of emergencies and acute surgical problems so that they may be managed in the best possible manner for the patient s benefit

Although there is no specific heading entitled "War Surgery " nevertheless within the pages of this book will be found discussions on those *injuries* sustained during warfare. In the same category of war injuries are those emergencies resulting from atomic bombing This subject and allied topics are included in this volume as future reference material May it never be necessary to use this knowledge however it is contained here if the need should arise.

All those associated with the creation of this book are worthy of our profound gratitude I know they do not desire any expression of gratitude for

the book itself is a printed manifestation of its own indebtedness to the authors The contributors have written for future generations gems of surgical knowledge which will alleviate the sufferings of mankind. The publishers have given a physical structure to these gems which encase them for preservation through the years Both authors and publishers have brought forth a book which is a credit to the printer's art It is hoped that their labors have not been in vain and that this book will be listed among the literary efforts which have contributed to the advancement of American surgical knowledge and prestige

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SECTION 1

EMERGENCIES ENCOUNTERED IN THE REGION OF THE HEAD AND NECK

John E Adams MD

1

Management and Treatment of Acute Injuries to Skull and Brain

THE magnitude of the problem occasioned by the *increasing frequency of* injuries to the head in times of both peace and war cannot be overemphasized. Although trephination of the skull for traumatic intracranial hemorrhage is one of the earliest recorded operative procedures, mankind's increasing propensity for self-destruction on the highway, in industry, and in war establishes the problem of head injury as a tremendous present day challenge. For example it has been estimated that head injuries account for seven per cent of the total number of cases receiving aid under workmen's compensation plans and thirteen per cent of the total compensation costs.

It is obvious that the vast majority of patients suffering an acute head injury must be cared for by physicians who are not engaged in the practice of neurological surgery. Reduction of mortality and morbidity can be accomplished only by constant dissemination of information about the mechanisms of injury, the altered intracranial physiology, and the principles of diagnosis and treatment.

The Injuring Force In order to treat the patient with an acute head injury intelligently it is necessary to have an understanding of the anatomical changes produced in the skull and its contents by the *injuring force*. No constant pattern of skull and cerebral injury can be predicted from the direction and force of the impinging trauma. However, within limits certain regions of the brain are more susceptible to injury than others and trauma is more likely to cause severe damage when directed to certain portions of the skull.

Deformation of the skull is greatest when the injuring force impinges upon the occipital region. Brain tissues tend to be injured along the *line of force* established by the direction in which the traumatizing agent strikes the head. However, blows to the head also produce rotation and swirling movements of the entire brain[2] which *are of greater mag*nitude in the parieto-occipital than in the fronto-temporal region where the brain is more firmly fixed in the frontal and middle fossae of the cranium. There is therefore a greater shearing force exerted toward the frontal and temporal lobes with an increased tendency to more severe and rect (coup re-coup) contusion and laceration of these parts of the brain.

The severity of the resulting brain damage is roughly proportional to the rate of acceleration or deceleration of

JOHN E ADAMS M.D

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Management and Treatment of Acute Injuries to Skull and Brain

THE magnitude of the problem occasioned by the increasing frequency of injuries to the head in times of both peace and war cannot be overemphasized. Although trephination of the skull for traumatic intracranial hemorrhage is one of the earliest recorded operative procedures mankind's increasing propensity for self-destruction on the highway in industry and in war establishes the problem of head injury as a tremendous present day challenge. For example it has been estimated that head injuries account for seven per cent of the total number of cases receiving aid under workmen's compensation plans and thirteen per cent of the total compensation costs.

It is obvious that the vast majority of patients suffering an acute head injury must be cared for by physicians who are not engaged in the practice of neurological surgery. Reduction of mortality and morbidity can be accomplished only by constant dissemination of information about the mechanisms of injury the altered intracranial physiology and the principles of diagnosis and treatment.

The Injuring Force In order to treat the patient with an acute head injury intelligently it is necessary to have an understanding of the anatomical changes produced in the skull and its contents by the injuring force. No constant pattern of skull and cerebral injury can be predicted from the direction and force of the impinging trauma. However within limits certain regions of the brain are more susceptible to injury than others and trauma is more likely to cause severe damage when directed to certain portions of the skull.

Deformation of the skull is greatest when the injuring force impinges upon the occipital region.[2] Brain tissues tend to be injured along the line of force established by the direction in which the traumatizing agent strikes the head. However blows to the head also produce rotation and swirling movements of the entire brain[3] which are of greater magnitude in the parieto-occipital than in the fronto-temporal region where the brain is more firmly fixed in the frontal and middle fossae of the cranium. There is therefore a greater shearing force exerted toward the frontal and temporal lobes with an increased tendency to more severe indirect (contre-coup) contusion and laceration of these parts of the brain.

The severity of the intrinsic brain damage is roughly proportional to the rate of acceleration or deceleration of

the brain at the time of injury It is this factor which produces the rotation and swirling described, and these movements, in turn result in the tearing of cortical blood vessels and perhaps deeper ones, with secondary hemorrhage

CEREBRAL TRAUMA The severity of the injury to the brain itself is the factor which determines whether the patient will survive the immediate effects of the trauma, and it is necessary to have a clear concept of the altered intracranial physiology due to the changes occurring in the brain.

Cerebral Concussion. Concussion is the least severe form of cerebral trauma It may be defined clinically as a transient alteration of or loss of consciousness following injury or in other words a transient disruption of neural function. The changes occurring in cellular structures as demonstrated by the work of Windle *et al* [4] are reversible and insofar as cerebral function is concerned recovery is complete The pathogenesis of cerebral concussion is still poorly understood, but an increasing body of evidence suggests a brief but pronounced rise in intracranial pressure at the time of the trauma as the causative mechanism

Cerebral Swelling It is probable that cerebral swelling follows mild injuries even though no gross pathologic alterations are demonstrable.[5] In instances of more profound cerebral injury particularly when complicated by the compressive effects of hemorrhage, cerebral swelling plays a major role in the production of a fatal outcome

By the term cerebral swelling is meant an increase in brain volume (Fig 1) It is not clear whether an increase in intracellular or extracellular fluid volume is responsible but the studies of Scheinker and Evans[6,7] force attention upon changes in the vascular tree secondary to the trauma as the initiating mechanism Three stages in the process are described which, however are not separate and distinct, but blend imperceptibly into each other (1) Vasoparalysis, generalized or local associated with increased permeability of the vessel walls for serous fluid and erythrocytes (Fig. 2) (2) degeneration and necrosis of vessel walls leading to secondary extravasation of blood into the surrounding tissue (Fig 3) and (3) chronic vascular changes The net result of these changes is an increase in the volume of affected brain, frequently resulting in transtentorial herniation of the uncus of the temporal lobe through the incisura of the tentorium causing secondary pontine hemorrhage and ultimately death These changes will be described more fully when the compressive effect of extradural hemorrhage is considered.

Contusion and Laceration. These terms indicate a greater degree of cerebral damage and are largely self explanatory They are invariably accompanied by cerebral swelling

CEREBRAL COMPRESSION Traumatic cerebral compression usually is caused by an expanding hemorrhage although intracranial abscess secondary to trauma is a less frequent space-occupying lesion The effects of the accumulating blood or fluid are twofold (a) A generalized increase in intracranial pressure with secondary cerebral compression and (b) focal effects dependent upon the site of the lesion.

Progressive cerebral compression from a hemorrhage unless adequately dealt with, causes a fatal outcome Initially there is compensation for the expanding mass by displacement of cerebrospinal fluid from the intracranial cavity and the intracranial pressure is not elevated As the process continues and compensa

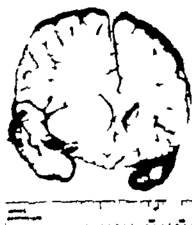


Fig. 1



Fig. 2

Fig. 1 Cerebral swelling due to large right sided extradural hemorrhage. Note enlargement of right hemisphere with shift of midline structures to the left.

Fig. 2 Distention of perivascular space by coagulated serum.

tion is no longer possible by this mechanism, venous compression occurs and the intracranial pressure rises Finally, with sufficient pressure to produce capillary anemia paralytic symptoms occur This progression is reflected by changes in the systemic blood pressure and pulse which Cushing demonstrated so beautifully [6]

Accompanying, *pari passu* the compressive effect of the expanding clot is the progressive swelling of the hemisphere The latter process may be initiated in part by the direct effect of the trauma to the brain but is aggravated by the vascular changes secondary to the expanding hemorrhage and if not checked soon becomes irreversible Early evacuation of the clot is therefore imperative, and a lapse of even a few hours may be fatal

The combined action of an expanding clot and the progressive cerebral swelling causes a shift of cerebral substance mesially and a displacement of the uncus of the temporal lobe through the incisura of the tentorium The venous drainage of the brain stem is thus compressed and the posterior cerebral artery may be involved with resulting infarction of the occipital lobe leading to further swelling The third cranial nerve is impinged upon which results in dilata

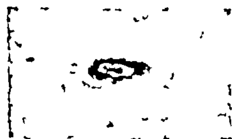


Fig. 3



Fig. 4

Fig. 3 Disintegration and necrosis of vessel wall. Note loss of cellular structure surrounding the vessel

Fig. 4 Drawing to show the relationship of the vessels lying between the uncus and the mid-brain which are compressed when swelling of temporal lobe occurs.

tion and fixation of the ipsilateral pupil. Ultimately edema of the brain stem is signalized by recurrent episodes of decerebrate rigidity and, finally pontine hemorrhages occur resulting in a fatality (Fig. 4)

TRAUMATIC INTRACRANIAL HEMORRHAGE An understanding of the pathophysiological events is essential for proper diagnosis and treatment of the patient with an acute head injury complicated by hemorrhage The sites of such hemorrhage can be conveniently divided into extradural subdural, subarachnoid, and intracerebral although this is an artificial subdivision since bleeding may be present in all of these spaces in a single case

Extradural Hemorrhage The most frequent source of extradural bleeding is a tear of the middle meningeal artery where it grooves the temporal bone low in the temporal fossa. Less frequently one of the major dural sinuses is the source The course in the latter instance is likely to be more chronic and the clot less extensive since intracranial venous pressure is low (being less than atmospheric in the upright position) Furthermore the outer layer of the dura which is adherent to the inner table of the skull, acts as a tamponade to expansion of the clot.

A blow which fractures the temporal bone tearing the artery is usually sufficient to produce initial unconsciousness from which the patient may or may not recover Within a few hours however deepening stupor or a decrease in the level of consciousness indicates beginning cerebral compression and a rising intracranial pressure A change in the level of consciousness is by far the most reliable index of this course of events and the state of consciousness therefore should be followed carefully and frequently after a base line has been established at the time of the initial examination. If the patient is unconscious when first seen and remains so the responsiveness to *strong supraorbital pressure* is a valuable guide The slowing of the pulse rise in blood pressure and respiratory irregularity indicate beginning decompensation and should not be waited for as occasionally they may be absent. Dilatation and fixation of a pupil indicate uncal herniation and may be followed by transient episodes of decerebrate rigidity When these signs appear evacuation of the clot is urgent. Focal signs which may be irritative (convulsions) and then paralytic (hemiparesis) aid in establishing the diagnosis and lateralizing the location of the clot.

In essence it may be said that any patient with a head injury who shows a progressing decrease in the level of consciousness particularly if accompanied by the development of focal signs should have burr holes appropriately placed without waiting for alterations in blood pressure pulse and respirations or the dilatation of a pupil.

Subdural Hemorrhage It may be impossible to distinguish clinically an acute subdural hemorrhage from an extradural hemorrhage However because the source of subdural bleeding is usually venous, signs of cerebral compression usually are delayed Chronic subdural hematomas may become manifest weeks months, or even years after relatively minor traumatic events and are therefore not pertinent to the subject of emergency surgical diagnosis and treatment. Since it is frequently impossible to distinguish preoperatively between extra and subdural hemorrhage the same principles apply to both in diagnosis and treatment. Thus, if a patient following head injury shows a deepening level of unconcious-

might be the source of a subsequent serious osteomyelitis of the skull and/or subdural meningeal, or cerebral infection The presence of such a fracture demands prophylactic antibiotic and chemotherapy



FIG. 5 Depressed fracture of the left parietal bone.

(3) Signs suggesting a complicating intracranial hemorrhage which cannot be localized clinically make careful x ray examination mandatory The discovery of a fracture crossing the middle meningeal groove or a major dural sinus or the disclosure of a calcified pineal gland which is displaced will aid in localizing the hemorrhage and simplify the surgical treatment

Other less common but nevertheless important abnormalities may be revealed such as traumatic pneumocephalus It is well to include examination of the cervical spine should there be any suggestion of a coincident injury such as deformity cervical rigidity marked cervical tenderness or paraplegia

Because of the frequency with which injuries result in litigation it is a wise precaution to obtain complete x ray examination of the skull at some time before the patient is dismissed A fracture is frequently of little or no clinical importance but in the eyes of the laity and the legal profession it assumes an importance of some magnitude.

LUMBAR PUNCTURE The routine use of lumbar puncture is to be condemned Although it has been stated that lumbar puncture is not hazardous in the presence of intracranial bleeding with increased intracranial pressure and its use has been strongly advocated, this author has seen several instances in which an injudicious spinal tap has resulted in a fatality There are situations, however in which the information to be gained warrants the careful performance of a lumbar puncture in order to measure the intracranial pressure and the amount of bleeding into the cerebrospinal pathways If meningeal infection is suspected examination of the cerebrospinal fluid is essential in order to obtain the offending organism for culture and sensitivity studies

The type of patient in whom the information to be gained justifies a lumbar puncture would be one who has remained unconscious from the time of injury and in whom there is doubt as to the presence of a complicating hemorrhage With careful technic some of the hazards of spinal puncture may be avoided A fine (No 22) spinal puncture needle is used and when it is felt penetrating the interspinous ligament the stylet is withdrawn and a water manometer attached to the needle The dura is then entered. Sufficient time is taken to obtain an accurate pressure recording (This of course, is impossible if the patient is restless and under these circumstances nothing is to be gained from a lumbar puncture) The

needle is then withdrawn and the fluid contained in the manometer is used for a cell count or culture. In this manner only a few cubic millimeters of fluid are withdrawn and there is but slight danger of causing herniation of the cerebellar tonsils into the foramen magnum and of producing or increasing the herniation of the temporal lobe through the incisura of the tentorium.

In such a case if the fluid is not under greatly increased pressure (less than 250 cm. of water) it is reassuring and further observation is warranted. A word of caution must be interposed at this point. In the presence of marked cerebral swelling and transtentorial herniation of the brain the measured pressure in the lumbar subarachnoid space may not at all reflect the true intracranial pressure, and a sense of false security may therefore be engendered.

The only therapeutic indication for lumbar drainage is in the patient who has signs of meningismus and severe headache from blood in the subarachnoid fluid spaces. There are those who advocate daily lumbar drainage to reduce increased intracranial pressure and remove the bloody cerebrospinal fluid. It is the author's opinion that this procedure has no value and may be hazardous.

SURGICAL TREATMENT. The surgical treatment of open and closed head injuries can conveniently be discussed separately.

Open Wounds. The principles applicable to the treatment of open head wounds differ in no way from those established for wounds in other areas of the body. Hemorrhage is most easily controlled by a pressure dressing which should be left untouched until the time of definitive care of the wound. Debridement, removal of foreign bodies, and probing of the wound are to be carried out only by the surgeon w... ing the definitive treatment. It is ... that these measures should not be ... taken unless the patient is pr... pared from the standpoint of ... replacement of blood loss. ... wounds except simple scalp ... should be treated in a fully ... operating room with the operator ... pared to deal with a serious brain ... if necessary.

Local anesthesia is the ... agent of choice if the patient ... cooperative. If there is ... and the patient's condition ... because of cerebral depres... sion, intratracheal anesthe... Intravenous barbiturates ... with caution in such ...

A wide margin of hair ... should be clipped and ... any question about the pres... cranial bleeding, the ... be shaved. The scalp ... cleansed with soap and ... an adequate antiseptic ... of the lacerated scalp ... with procaine follo... wound is thorough... point it is wise to ... gown and redrape ... all previously used ...

The wound is then ... cluding devitalized ... meninges and brain ... All depressed fra... which may have pe... lacerated the brain ... The reason for th... cerebral wound ... with a cortical me... of later convulsi... version into a cle... incidence of p... greatly reduced.

Laceration of

a depressed fracture is apparent during the debridement of an open wound. The diagnosis of depressed fractures in closed injury may be most difficult without adequate roentgen examination At the edges of a cephalohematoma a depression can often be palpated which is merely edema of the scalp and does not necessarily signify a fracture In such instances the extent of the depression of the inner table of the skull as judged from x ray examination or the presence of blood in the cerebrospinal fluid may indicate dural and cortical damage and the need for elevation of the fracture The electroencephalogram may be of aid in this problem since mere depression of the inner table of the skull over intact meninges and brain will rarely produce focal electroencephalogram abnormalities

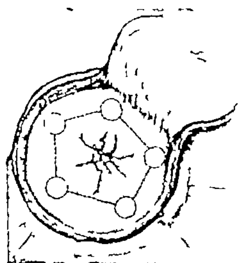


FIG. 6. Impacted depressed fracture at operation. Due to impaction of fragments their elevation and removal is made difficult, necessitating removal *en bloc* as a free bone flap

If the depressed bone fragments involve a dural venous sinus they must be manipulated with great care to avert an excessive hemorrhage or air embolism When impaction of the depressed fragments makes it impossible to elevate them, burr openings may be placed circumferentially about the fracture site and connected with the Gigli saw and the fractured bone can then be lifted away in one piece (Fig. 6) It is frequently possible to replace the bone thus removed. If the bone is fragmented the several pieces may be laid over the dura and the subsequent reparative process particularly if there is attached pericranium may be astonishing Naturally no bone should be replaced if contaminated by dirt, hair or foreign bodies.

Debridement of the brain is accomplished by gentle irrigation and suction All necrotic and devitalized brain tissue should be removed The dura should then be closed if at all possible Sometimes it is not possible to do this without splitting the remaining dura and swinging the outer layer over the defect. If there is insufficient dura, temporal fascia, fascia lata, or dural substitutes can be utilized The question of drainage is a matter to be decided in each individual case in accordance with established surgical principles

The subject of penetrating wounds of the head by missiles has been thoroughly covered by Matson in a recent monograph.[1] Such injuries are infrequently encountered in civilian practice and will not be discussed here

SURGICAL TREATMENT OF CLOSED INJURIES Three specific categories of closed injury are encountered which require surgical treatment

Depressed Fractures The treatment of closed depressed fractures and laceration of the brain has been discussed already When the fracture involves an accessory air sinus (Fig 7) a definite hazard of complicating infection presents itself To obviate this hazard the mucous membrane of the sinus must be exenter

ated and final repair of the skull defect, if present, must be delayed for several months

Rhinorrhea and Otorrhea. The presence of rhinorrhea and otorrhea indicates a basal skull fracture through the frontal or middle fossa respectively Formerly this was considered a surgical emergency and repair of the defect in the dura a necessary prophylactic measure to prevent subsequent intracranial infection Today however the wiser procedure is to temporize, giving antibiotic and chemotherapy, since in most cases the leak will stop spontaneously in a few days If possible a sitting position in bed should be maintained at all times to lower intracranial pressure and thereby reduce the tendency for cerebrospinal fluid leakage. The nose and ear should not be irrigated or tampered with but may be kept clean by gentle wiping with sterile cotton The patient should be prevented from blowing his nose forcibly or straining unduly



FIG. 7 Depressed fracture of frontal bone involving the frontal sinus.

Intracranial Hemorrhage No exact data are available but it is probable that in the neighborhood of ten to fifteen per cent of patients suffering injuries to the head have complicating intracranial hemorrhage necessitating surgical treatment. An unrecognized intracranial hematoma is the largest single factor in the unnecessarily high mortality associated with head injuries today For this reason the recognition and diagnosis of this complication of head injuries is by far the most important step in the treatment of these patients

If the course of events is such as to raise the question of an accumulating hematoma, it is the most conservative procedure to place exploratory burr openings without delay an undertaking which has been aptly called "woodpecker surgery." Such an operation is best carried out in an operating room fully equipped to handle major neurosurgical procedures and by a surgical team trained in this specialized form of surgery Again, the anesthetic agent of choice is local anesthesia unless the patient is too restive to cooperate We prefer the supine position with the head supported by a head rest and sand bags in such a manner as to allow ready access to any part of the calvarium (Fig 8) The entire head is shaved.

If the presence of an epidural hemorrhage is suspected, temporal openings are made first If extradural bleeding is found it is usually necessary to enlarge the opening, frequently down to the base of the skull where the middle meningeal artery is visible as it passes from the foramen spinosum The artery may be clipped ligated, or coagulated at this point The remaining clot should then be thoroughly evacuated.

When the bleeding is subdural burr openings should be placed in the frontal temporal, and occipital regions of the skull If the hematoma is fluid it can then be readily evacuated by through and

through irrigation It is mandatory to carry out bilateral exploration since subdural hematomas are found bilaterally in over one half the cases If after evacuation of the clot the brain fails to expand properly drainage of the subdural space by small rubber drains is advisable to prevent re-accumulation of the hematoma.

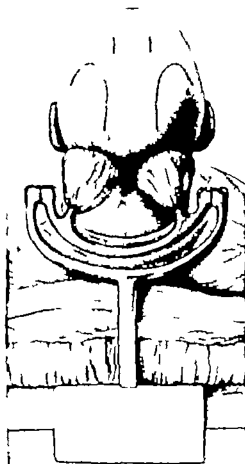


Fig. 8. Position of head and incision for exploratory burr holes. Should the hematoma be solid and impossible to evacuate by through and through irrigation, the incision may be connected (dotted line) so as to form a scalp flap and a small bone flap turned to provide readier access to the subdural space.

When swelling of a contused temporal frontal lobe is excessive resection of a sufficient amount of brain to provide an internal decompression and thereby relieve brain stem compression may be a life-saving procedure since evacuation of the clot alone may be inadequate

General Care In no other field of medicine is proper nursing and medical care based upon sound physiological principles more important. It is usually the factor which tips the scales in either direction Special nursing is obligatory in the critical case

The vascular and parenchymal changes which lead to cerebral swelling may not be initiated but are certainly augmented by hypoxia. Consequently the prevention of cerebral anoxemia, which can occur without visible evidence of cyanosis in other tissues is the prime objective of treatment. The following considerations are important in this regard.

Maintenance of Systemic Circulation Since the brain is dependent upon the systemic circulation for its blood supply shock when present must be combated vigorously

Maintenance of an Adequate Airway Prevention of accumulations of respiratory secretions should begin as soon as the patient is seen Scrupulous attention to prophylactic measures will be repaid Better drainage of secretions from the bronchial tree is obtained with the patient in a lateral position on a flat bed. Unfortunately it is desirable to elevate the head in order to facilitate venous drainage and reduce intracranial pressure A compromise must therefore be secured by elevating the head as much as possible and intermittently lowering it to permit drainage of secretions.

The respiratory passages are kept open by (1) an oral airway by which the tongue is held forward and pharyngeal obstruction prevented (2) intermittent aspiration of the pharynx and upper trachea. For this purpose gentle suction

through a small rubber catheter is most efficient. (3) The use of oxygen *via* a nasal tube. The semiconscious patient will usually fight a mask and an oxygen tent makes nursing care difficult.

If in spite of the above measures respiratory movements continue to be labored and particularly if visible cyanosis of the mucous membranes persists, more stringent measures must be applied. Bronchoscopy, intratracheal intubation, or tracheotomy may be life saving.[10]

Control of Temperature. Hyperthermia raises the metabolic rate of tissues and thereby increases the oxygen requirement of the brain in a patient already at a critical level of oxygen utilization. Hyperthermia beginning shortly after the injury indicates either intrinsic damage or compression of the brain stem. It is a poor prognostic sign and must be combated vigorously, since an unchecked fever leads to peripheral circulatory collapse, further reducing the blood supply to the brain.

If the temperature (rectal) rises to 101.3 F (38.5° C.) bed clothes should be discarded. Frequent sponges with tepid water or alcohol combined with ice packs to the groin, axillae and the region of the great vessels of the neck are next in order. If the temperature fails to fall, all clothing should be removed from the patient and air fanned over him continuously. Acetylsalicylic acid in doses of 0.6 to 1 Gm. (10 to 15 grains) inserted in the rectum may be of value.

Fluid Balance. The physiological requirements of the patient are best served by maintaining the fluid intake to offset the losses *via* the lungs, perspiration, the kidneys, and the gastrointestinal tract. From two to three liters (quarts) of fluid per day are usually sufficient and of this amount not more than 1000 cc. (1 quart) should contain saline, unless sodium or chloride loss has been excessive. The urinary output should be measured daily and not allowed to fall below 1000 cc. per day. (See Chapter 54.)

The author firmly believes that dehydrating regimens do not reduce cerebral edema sufficiently to warrant inviting the disturbances in fluid and electrolyte balance which necessarily follow. Likewise an excessive fluid intake enhances cerebral edema and hence is harmful.

Nutrition. In order to prevent the depletion of body stores of protein, the passage of a polyethylene or Levine tube into the stomach should be carried out as soon as the danger from vomiting has passed. From this standpoint, tracheotomy has distinct advantages since it obviates the risk of aspiration of vomitus. A formula high in carbohydrate and protein content can then be fed, beginning with frequent small feedings.

Insofar as the further care of the patient is concerned, attention to the skin, frequent turning, prevention of distention of the bladder and care of the bowel are features which are common to the care of any unconscious patient.

In summary it may be loosely stated that approximately sixty five per cent of the patients sustaining injuries to the skull and brain will recover with adequate nursing care, one tenth will succumb despite all efforts, but in the remaining twenty five per cent the outcome will be determined by the diagnostic acumen, the surgical skill and the vigilant care provided by those in charge.

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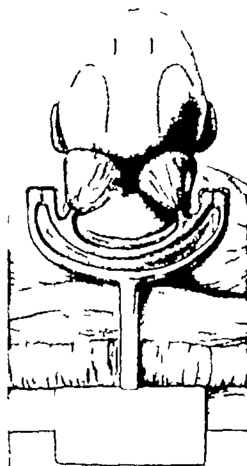


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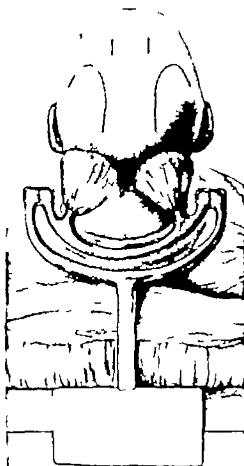


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2

States of Consciousness After Craniocerebral Trauma

A discussion of any subject is well begun with a definition of terms. Consciousness, unfortunately, is somewhat like the atom bomb—not everyone can define it, although everyone thinks he knows what it is. While a study in semantics is beyond our purpose, yet there is some necessity for clarification of the terms to be applied to the several degrees of consciousness state observed following injuries to the head. Such characterizations as stupor, semicoma and coma [illegible]

Degrees of Consciousness [illegible]

1. The normal individual is responsive to some in the most subtle sense of the expression. He is not only talkative but conversational and—as far as speech reveals—his ratiocination is unimpaired. In common medical terms such a person is usually characterized by the classic phrase "alert, oriented, and cooperative."

2. Just below [illegible] level is the condition best described as [illegible] confused. The patient in this category is alert and frequently [illegible] from the normal [illegible]

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2

States of Consciousness After Craniocerebral Trauma

A DISCUSSION of any subject is well begun with a definition of terms. Consciousness unfortunately is somewhat like the atomic bomb—not everyone can define it although everyone thinks he knows what it is While a study in semantics is beyond our purpose yet there is some necessity for clarification of the terms to be applied to the several degrees of conscious state observed following injury to the head Such characterizations as stupor semicoma and coma give a rough idea of the condition referred to but their significance is not accurately transferable from one observer to another since everyone has his personal idea of what 'stupor or coma denotes When one examines a particular patient for the first time, and is concerned with fluctuations in the state of consciousness, it is at least frustrating to find the previous condition described loosely as unconscious

Degrees of Consciousness In general the state of awareness is evaluated by three criteria Response to voice motor activity and response to pain It is in terms of these that a patient s condition should be described for clinical purposes On such a basis one may then observe approximately five degrees of consciousness

1 The normal individual is responsive to voice in the most subtle sense of the expression He is not only talkative but conversational and—as far as speech reveals—his ratiocination is unimpaired In our medical cliches such a person is usually characterized by the classic phrase "alert, oriented, and cooperative "

2 Just below this in the scale is the condition best described as slightly confused The patient in this category is quite alert and frequently euphoriously cooperative but his actions separate him from the normal While he may walk about the ward and carry on a shallow conversation he mistakes the kitchen for the bathroom or climbs into another patient s bed Although he provides comic relief or the ward, he also constitutes a pitfall for the unwary Rapid rounds on a busy service with a casual "How are you today? " frequently fail to reveal the true state of affairs The patient is quite capable of answering and the commonly associated euphoria makes the answer favorable It is only by more intimate and prolonged contact that the abnormal condition is revealed Sometimes the ward nurse is more aware of the actual situation than the busy resident, and the house officer who received a cheery answer of

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produce loss of consciousness has not yet been clearly evaluated. Some of the mechanical and electrical effects of trauma, however have been thoroughly studied in experimental fashion. A blow to the head is known to produce deformation of the skull, sudden increase of intracranial pressure linear and rotational motion of the brain in relation to the skull, and increase of electrical potential at the cerebral cortex.[6,12,14] Some observations in dogs indicate that unconsciousness supervenes only when the intracranial pressure is raised (either by a blow or by other mechanical means) beyond the level of the systolic blood pressure.[12] This and other considerations have led to the assumption that trauma produces its effect upon consciousness through the mechanism of cerebral ischemia. The observation of high electrical discharges from the cortex at the moment of impact has produced the thought that the immediate effect of trauma is excitatory not suppressor This concept is perhaps supported by the similarity between recovery from unconsciousness following trauma and recovery from that following a convulsive seizure [13]

The theoretical explanations of how trauma exerts its direct effect on the brain have been summarized and discussed by Rowbotham.[11] They are three

1 Vascular disturbance It is assumed that the compressive force causes either temporary obliteration of the capillaries, or impairment of the neuromuscular mechanisms of cerebral blood vessels The latter results in dilatation then constriction. It is difficult to reconcile this theory with the demonstrated fact that cats may be subjected to complete circulatory arrest (by occlusion of the pulmonary artery) for more than three minutes without apparent neurologic residuum.[6]

2. Structural neuron injury This theory attributes cerebral dysfunction to anatomical derangement of the neuron and its processes—by compression or stretching

3 Functional neuron injury It is known through numerous investigations that animals may succumb to cranial trauma which produces no demonstrable anatomical alterations in the brain. A similar situation is not uncommonly seen in humans This has led to the concept that trauma may on occasion, cause only functional changes in the brain. Such a concept, of course, is decision by default, and is permitted only by the inadequacy of available methods for examining the tissue It is at least possible that one is dealing in this instance with structural changes on a molecular level. Whatever the mechanism by which trauma exerts its influence may be, it must in some fashion be self-propagating, since trauma enduring for only a fraction of a second may produce unconsciousness persisting for minutes without other known causative factor

Secondary impairment of the conscious state (delayed, recurrent, or increased depression after partial recovery from the initial phase) may be attributed to space occupying changes within the cranial vault or to involvement of the diencephalon. There is ample evidence that diencephalic lesions may result in hyper somnolence[4,5,7] and to this (alone or in company with space-occupying lesions) must be ascribed the depression of awareness in some cases of cranial trauma. The outstanding cause of secondary impairment of consciousness however is consumption of space by additions to the contents of the cranial vault, and the consequent embarrassment of the structures normally contained therein The offending elements are fluid collections and swelling of brain tissue. Fluid collec

"Fine Doc" in the morning may find the patient almost moribund at night. Another deceptive feature of this condition is the fact that it may persist for several days before the almost inevitable decline makes itself evident.

3 The third stage is one of apparent drowsiness The patient responds to voice and to pain but not with the anticipated briskness There is a paucity of activity Conversation can be carried on, but the observer must speak a bit more loudly or insistently If the patient's attention is not retained by repetition of questions or by auxiliary stimuli he tends to close his eyes and ignore questions, or answer them only partially As a rule, this condition seldom persists more than a day or two before it deteriorates into a gross impairment of consciousness, should the offending lesion not be removed. Such a patient is usually termed drowsy lethargic or semistuporous

4 A more profoundly abnormal state is demonstrated by the patient who is responsive to pain but barely responsive to voice This person may move irregularly and actively about the bed and react with rather violent defensive movements to painful stimuli such as pinching or pricking, but shows little significant response even to the calling of his name. This state is usually referred to as deep stupor or semicoma and, with slight fluctuation, may persist for twenty four hours or more

5 The most intense depression of consciousness is characterized by no response to voice and practically no reaction to pain. Sometimes, although there is no grossly obvious reaction to noxious stimuli careful observation will disclose an increase in pulse or respiratory rate following application of pain Too distention of the urinary bladder or partial obstruction of the respiratory tract with mucus may result in irregular restless movements This condition is usually termed coma, or deep stupor With equal validity it may be called moribund it seldom persists for more than a few hours and is commonly followed by death

The above classification is arbitrary and, to some extent, rather crude There are gradations between various groups, and not all of the alterations of consciousness are included. One occasionally sees, for example, the condition called coma vigil, in which a patient lies in little or no apparent distress with the eyes widely opened as though he is observing the passing scene, yet he makes no response to visual or auditory stimulus Nevertheless, the classification serves a purpose by indicating the states most commonly seen after craniocerebral trauma. We strive for brevity we search for the one word which will accurately portray the *condition to be described—but in this* instance the one word is seldom available If one wishes to transfer his impression to the next observer in valid and utilizable form, it is necessary to describe the conscious state of a specific patient in several words, or several sentences The added effort is repaid in the evaluation and treatment of craniocerebral injuries, few factors are as significant as the alterations of consciousness

Production of Unconsciousness There are two mechanisms by which craniocerebral trauma produces loss of consciousness The first is a direct effect of the traumatic force upon the brain. If it occurs at all, it occurs immediately though its effect may persist for some time The second is an indirect result and arises later from the pathologic changes within the cranial vault which, themselves, have been produced by the trauma.

Precisely why a blow to the head should

an undue facetiousness, an occasional irrational action or statement—something which indicates impairment of cerebral activity At the end of the interval, there appears progressive deterioration Unless surgery is carried out, the patient passes through the various stages of depression to complete unresponsiveness and death. The deteriorative phase consumes several hours and, occasionally several days Such a syndrome is frequently caused by subdural collections,* but may also result from cerebral laceration and intracerebral hematoma. In an occasional instance, a patient with epidural hematoma may pass through an interval of several days or a week

In general, the duration of the interval seems to be determined by the rapidity with which the space-occupying lesion forms and the size to which it attains Brisk hemorrhage and large collections of blood from a ruptured middle meningeal artery or a large cerebral vein usually permit only a short interval between the primary and secondary periods of unconsciousness Smaller epidural or intracerebral collections or venous bleeding that produces a hematoma with relative slowness may permit a long interval.

3 Some patients who have received severe craniocerebral injury do not lose consciousness at the time of injury After a period varying from several hours to several days however a gradual depression of consciousness appears Without surgical intervention, the condition progresses to death. When the ultimate downward progression begins shortly after injury it proceeds rapidly If its onset is delayed for days rather than hours, it may proceed less rapidly This course of events is seen in cases of subdural collection* and intracerebral hematoma

4 The final group includes those patients who lose consciousness at the time of injury and remain so until death, which ordinarily occurs a few hours later This course of events results from gross and/or multiple alterations of the brain In some cases, the internal derangement of the brain is so great that the patient never recovers from the initial period of unconsciousness In other cases hemorrhage is so rapid and so extensive that the secondary phase of unconsciousness becomes effective before the initial phase has disappeared, so to speak.

Practical Considerations It is apparent that the foregoing evaluation of patients depends in some measure upon historical information relative to the mode of injury and the events following it. In civilian practice, the greater number of injuries occur among the less fortunate socio-economic classes and it is usually in these classes that historical detail is least available The results of injury are clouded by the effect of alcoholism The patient is found unconscious in the park or the dark alley and no one knows what happened, or when. Many times the precise picture of the sequence of events can not be obtained. In such instance one must rely more heavily on serial observations, or on other factors It is obvious also that no particular syndrome can be considered as pathognomonic of any particular intracranial lesion. Nevertheless in the evaluation of craniocerebral trauma, and in the planning of its management, alterations in the state of consciousness remain the outstanding signposts

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tions consist of whole blood diluted blood, or colorless fluid (which is considered to be cerebrospinal fluid)[2,3] They may exist in the extradural or subdural spaces or within the tissue of the brain itself It is questionable that they ever exist in the subarachnoid space in surgically significant amounts Swelling of the brain occurs about a destructive lesion such as contusion or laceration and may often arise in the white matter subjacent to an extracerebral fluid collection despite the apparent absence of any destructive lesion of the brain itself

Clinical Syndromes On the basis of alterations in consciousness patients who have sustained craniocerebral trauma may be divided into five groups

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2 The combination of craniocerebral injury followed by an initial period of unconsciousness partial or complete recovery and then a recurrent impairment of consciousness is referred to as the "interval syndrome and the period of improvement following the initial unconsciousness is the lucid interval For clinical purposes the interval syndrome should be subdivided according to the length of the interval

a Short interval In this group the lucid interval lasts usually for only a few hours but sometimes as long as twenty four or thirty-six hours During the lucid interval the patient may be quite well eventually however there appear severe headaches, perhaps vomiting, and then lethargy which quickly progresses to death unless surgical intervention is carried out. At one time, such a syndrome was considered typical of epidural hematoma It has long been known, however that less than half of the patients with epidural hematoma have a classical in*terval syndrome*[10] *On the other hand* the syndrome may result from collections in the subdural space intracerebral hemorrhage and large contusions or lacerations of the brain.[1,8]

b Long interval. Although patients whose relatively lucid interval persists for days (and sometimes for two weeks) still present the "interval syndrome, clinical *considerations dictate that they be sep*arated from the patients with short intervals In the latter case the preservation of life requires early recognition of the situation and rapid surgical treatment When the interval is long, the clinician has more time to appreciate the abnormal situation surgical treatment can be instituted more deliberately and the unwary can be lured into a false sense of security by the relatively good condition of the patient. Although the interval may be long, it is seldom lucid in the strict sense of the term. During the interval the patient may be ambulatory and conversational, but he is rarely normal. There is a paucity of activity a tendency to sleep

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Practical Considerations It is apparent that the foregoing evaluation of patients depends in some measure upon historical information relative to the mode of injury and the events following it In civilian practice the greater number of injuries occur among the less fortunate socio-economic classes and it is usually in these classes that historical detail is least available The results of injury are clouded by the effect of alcoholism The patient is found unconscious in the park or the dark alley and no one knows what happened, or when Many times the precise picture of the sequence of events cannot be obtained In such instance one must rely more heavily on serial observations or on other factors It is obvious, also that no particular syndrome can be considered as pathognomonic of any particular intracranial lesion Nevertheless in the evaluation of craniocerebral trauma, and in the planning of its management, alterations in the state of consciousness remain the outstanding sign posts

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HANS MAY, M.D

3

Treatment of Wounds and Lacerations of the Face

WOUNDS of the face are either simple or compound They either involve the soft tissues including the eyelids, cheeks lips glands, tongue, neck, ear and the face, or soft tissues and the underlying frame work. All maxillofacial wounds are in fected, hence, in the treatment of these wounds one must realize two facts, one a traumatic wound is an *emergency* two a traumatic wound is contaminated. The treatment of a wound can be divided into emergency treatment and definitive treat ment. Anyone who undertakes the emer gency treatment should be cognizant of the fact that he harms more than helps if he secondarily infects the contaminated wound by rough handling or touching it with the fingers or covering it with soiled clothes or if he uses antiseptics The emergency treatment mostly consists of control of hemorrhage

The final treatment should be carried out as soon as possible, that is, as soon as the patient is admitted, unless he is in shock which must be treated first. The final treatment of the wound consists either of its excision or débridement. Wound excision is permissible *only* within the stage of contamination, which is within the first ten hours However dé bridement, *i.e* removal of retained debris is permissible at a later period There fore wound excision and débridement are not synonymous terms

Although the general rules in treating maxillofacial wounds are the same as in wounds elsewhere in the body they never theless require special consideration. There are certain points that should be emphasized. These follow

Anesthesia If possible, the anes thesia should be a general one through nasal or oral endotracheal inhalation or intravenous pentothal sodium with nasal or oral endotracheal intubation The endotracheal tubes assure the patient an adequate airway and permit a satisfac tory surgical field. If a tracheotomy is performed during the emergency stage, the anesthesia is given through the trache otomy tube If one has reason to expect vomiting, a Levine tube should be in serted. The stomach should be aspirated and the tube should be left in place Blood should be prevented from entering the larynx and trachea by packing off the pharynx.

With the exception of patients having evidence of cerebral injuries a most thorough repair of the wounds should be performed to obtain a minimum of defor mity and disfigurement The entire face

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is cleansed with soap and water In abrasions impregnated with dirt or oil a hand brush should be used and the area scrubbed thoroughly with proper solvents to avoid tattoo marks Excision of the wound should be as economical as possible One should investigate and if necessary should repair such important structures as muscles bones, and Stenson s duct. Bone fragments should be replaced

Fixation Early fixation of fractured jaws aims at the restoration of the original occlusion of the teeth or of the function of mastication temporary reduction and fixation may be obtained by simple bandaging or by wiring the teeth (Ivy) Impacted and depressed fragments (orbital, zygomatic arch, nose) are elevated. Application of special appliances if not immediately available and final immobilization of fractures of the jaws or nose may be delayed for a few hours after the wound has been sutured

Suture Closure of the wound should be thorough Deep sutures with fine suture material (silk, cotton chromic catgut) may be necessary to approximate important structures Fine silk or nylon is used for suturing the skin. Known points if present (vermilion border of lips nostrils, rim of eyelids) are approximated first thus facilitating accurate closure of complicated wounds The sutures should not be too close to each other No drain is inserted except in compound fractures of the jaws, which should have dependent drainage

Reconstruction in Extensive Injuries. Extensive Loss of Soft Tissue and Bone If the soft tissue defect cannot be closed by the use of local flaps the necessary reconstructive steps are as follows (Ivy) (1) Arrest of hemorrhage counteracting loss of control of tongue and thus danger to respiration is avoided by pulling the tongue forward either with a suture or safety pin anchoring the dressing débridement of the wound and wound excision if necessary fixation of bone fragments in approximate normal position by wires or other extraoral appliances adjustment of torn tissue flaps dependent drainage and systemic administration of antibiotics (2) Final reduction and fixation of the fragments of the mandible by special splints (such as those made of acrylic resin) afford a clear view of the underlying teeth and gum tissue and provide feeding space (3) After all wounds look clean and healthy a flap is transplanted to cover the soft tissue defect. (4) Three months later bone defect is replaced by bone transplantation unless there has been infection, in which case one ought to wait six months before transplanting bone and to provide preoperative and postoperative administration of antibiotics (5) Artificial dentures to replace lost teeth should be provided.

Concerning the choice of flaps the open acromiopectoral one is most suitable Local flaps if available are utilized to replace the missing lining. These flaps may be taken from the cervical region with the base at the tongue and hinged upward. If local flaps for lining are not available the pectoral flap is constructed so that the peripheral pedicle is folded over

Specialties. Lips Traumatic defects and wounds of the lips unless grossly infected should be sutured primarily regardless of the lapse of time Excision of the ragged wound edges should be made as sparingly as possible Whenever the full thickness of the lip including the vermilion border is severed, accurate suturing of the different layers is of the utmost importance The first su-

ture to be placed is through the mucocutaneous junction of the vermilion border Traction on the suture causes the other structures to fall into line Mucous membrane and muscle layers are sutured from the buccal side with an on-end mattress suture of cotton or silk through both layers Skin and vermilion borders are closed with silk. No dressing is required The skin sutures are removed on the third day mucous membrane and muscle sutures on the eighth day

coronary artery The latter must be preserved since it is the only nutrient artery This method was first devised by Estlander The technic is outlined in Fig. 1 A few important points however need to be emphasized. The flap itself should be outlined opposite the defect within the nasolabial region. The length (height of the flap) should be equal to that of the defect, but the width should be only half that of the defect in order to shorten the upper and lower lip proportionately The pedicle of the flap



FIG. 1 Closure of triangular defect of lower lip with flap from upper lip in defects not larger than one half the width of lip Defect includes lower border of left angle of mouth. To close defect, a vermilion-border-lined flap is rotated from upper lip and nasolabial region. Pedicle of flap containing the coronary artery is to replace the commissures of mouth. Flap should be made one-half as wide as defect to shorten upper and lower lip proportionately Flap is rotated into defect. Secondary defect is closed by suturing wound edges together

If the defect is so large that closure would result in an extreme shortening of the lip and the defect is vertical and is not larger than one-half the width of the lips such a defect is best closed immediately with a flap which is rotated from the opposing lip into the defect. The flap is pedicled at one side of the vermilion border which contains the

comes to lie at the median side After the flap is rotated and sutured in place it remains attached in this position for three weeks If the pedicle crosses the mouth it must be severed, which is done at that time followed by adjustment of the pedicle as well as of the base of the flap to the vermilion borders In larger defects requiring complicated plastic

repair methods, it may be best to wait several weeks before planning and carrying out the proper procedure

NOSE Defects of the nasal skin, if superficial should be replaced immediately with a skin graft. The type of graft is the thick split graft. If however the entire skin over the nasal framework is absent including the periosteum and perichondrium in other words, if bone and cartilages are exposed, a flap should be transplanted rather than a graft. If possible, the flap should be taken from the immediate neighborhood since the latter has the great advantage of tissue resemblance and quick healing For example a flap can be rotated from the cheek for larger defects of skin over the ala or in preparation for alar reconstruction if the defect is composite The flap is mobilized from the nasolabial region as demonstrated in Fig 2 It can be rotated immediately upon the nose if the traumatic defect consists only of full thickness loss of skin. If the entire ala is gone the flap is elevated and its raw undersurface is covered with a thick split skin graft, which will provide the lining. The flap is then returned to its former place and a pressure dressing is applied. One week later it can be elevated and now rotated into the defect. Full thickness skin losses over the ridge of the nose



FIG. 2. A Repair of defect of entire ala with flap which is rotated from adjacent cheek (Dieffenbach) Pedicle of flap is placed so that after rotation it forms base of ala. Flap may need to be raised in stages if circulation is inadequate. It is lined with a thick split graft and returned to its original site. B One week after flap has been lined, it is rotated into the defect, and the secondary defect at cheek is closed by skin-sliding.

are best closed with a forehead flap which can be raised and transplanted immediately Two parallel incisions are made over the forehead from 12 to 25 mm. (½ to 1 inch) apart, extending from the hairline to just in front of the eminence of both sides The flap is raised and when it reaches the eyebrows blunt dissection is carried downward almost to the root of the nose, thus saving the frontal vessels from injury The donor area is closed by wide undermining and by making one or two incisions under the undermined skin parallel to the incised edges through the fascia but without penetrating all of the subcutaneous veins or any of the skin This procedure of relaxation incisions through the fascia will allow approximation of the borders of the wound without undue tension. For larger full-thickness skin defects it may be best to wait with the final repair since they require larger flaps either from the forehead or from the arm, and these flaps must be raised in stages.

Eyes General principles of repair are the same as for wounds elsewhere on the body It should be emphasized, however that wounds of the eyelids should be closed as precisely as possible. While closure of the horizontal wounds does not offer any difficulties, vertical ones may involve problems, particularly if the full thickness of the lid is involved. If the wound edges are ragged, they should be excised, however as sparingly as possible If in vertical wounds parts of the lid are damaged and must be removed the defect should if possible be made triangularly with the base of the triangle at the lid margin.

The wound edges are sutured in layers the first suture consists of silk, is passed through the lid margins and approximated as accurately as possible The suture is not tight but used as a traction suture If pull is now exerted upon this suture the corresponding structures will fall in line with each other and are then sutured. Conjunctiva and tarsus are approximated with buried sutures of 00000 chromic catgut or fine cotton, in such a way that the sutures are passed through the tarsus only and tied upon it. Then follows suture of the orbicularis muscle (with the same material) and of the skin (with fine silk or nylon)

In larger wounds there is danger of notching of the lid margins To avoid this the skin defect is made either elliptical, or according to Wheeler's suggestion to place the two rows of sutures in different planes—in carpentry called "halving" (Fig 3) This is done as follows A small triangular piece of skin including lateral margin and orbicularis muscle is excised from one wound edge (the base of the triangle is at the lateral margin) and a similarly shaped piece of conjunctiva and tarsus is removed from the opposite wound edge If the lesion is near the outer canthus the skin and orbicularis muscle excision should be made from the lateral wound edges. If the lesion is near the inner canthus it should be made from the median wound edge The conjunctivotarsal layer is sutured first, then follows suture of the orbicularis muscle, the skin sutures starting at the margin with accurate marginal approximation thus skin and orbicularis flap overlap the conjunctival one. After-treatment consists of instillation of yellow mercuric oxide ointment into the conjunctival sac· the wound is dressed with sterile gauze· and eyepads are applied to both eyes to counteract overmotility The skin sutures are removed on the fourth day but the mar

ginal suture should remain in place for ten days

If the defect consists of loss of the skin of the eyelids, the defect should be closed immediately by skin grafting The skin graft is either removed from the posterior surface of the ear as is a thick split graft from a hairless region of the upper arm A pressure dressing is applied over the graft consisting of mechanics waste which is held in place by tying the interrupted sutures over it This dressing remains in place for one week

In large full thickness defects of the eyelids it is best to wait with the reconstruction since they inevitably require the transfer of lined flaps either from the immediate neighborhood or from distal parts of the body

EARS The majority of wounds of the ear involve its entire thickness If a part of the ear has been partially severed and is still hanging on a small pedicle it is worthwhile to save this part and suture it carefully in place The ear is supplied abundantly with vessels and even a narrow pedicle may carry sufficient circulation to keep the partially severed part alive

In smaller and medium-sized full thickness defects of the rim of the ear closure of the defect should be done immediately by transfer of a flap taken from the mastoid region and pedicled posteriorly This flap remains in place for three weeks and can then be severed

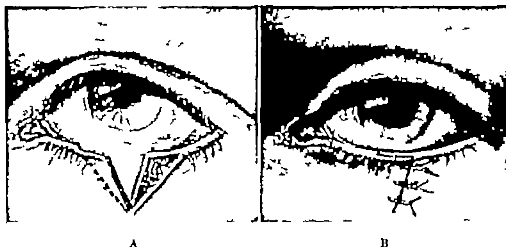


FIG 3 A V-shaped coloboma repaired by "halving method (Duverger Wheeler) that is, suturing skin and conjunctiva at different planes. Small triangular piece of skin (including lid margin) and orbicularis muscle is removed from lateral wound edge while similarly shaped piece of conjunctiva and tarsus is removed from median wound edge (dotted line) B Closure of wound in layers.

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4

Emergency Treatment of Facial Bone Fractures

FACIAL bone fractures constitute an emergency Increasing automobile accidents have made every small community hospital a general hospital and every general surgeon a potential maxillofacial surgeon. If severe facial deformities are to be avoided, facial bone fractures must be reduced early for accurate reposition and restoration to the normal facial configuration and function Each day of waiting makes the task more difficult. After fifteen days reposition is a problem after thirty days correction of the deformities is a formidable operation

The passenger in an automobile is the most frequent victim of facial bone injuries Sitting beside the driver his head can strike the dashboard if the car stops quickly the forward force drives the face forward and downward shattering facial bones. Our studies show the nose and mandible to be the most commonly fractured bones, the malar zygoma, and maxilla following in succession Often the fractures are multiple In contrast, a direct blow by a fist or bottle will usually fracture one bone only

For the purpose of clarity and simplicity we have chosen the tried and most accurate methods for the treatment of these fractures We feel the minimum of special equipment should be needed We have discarded cumbersome splints, headcaps, and gadgets as unnecessary and inadequate for good cosmetic and functional results Every small hospital can have the necessary materials needed by adding but a few things to the general surgical instruments found everywhere

Teamwork by associated specialists is needed to treat the many injuries accompanying those to the facial bones The services of the dentist are of tremendous value He makes up an important member of a maxillofacial team Other specialists, such as the neurosurgeon, orthopedic surgeon and eye surgeon should be consulted freely in the treatment of complicated cases

Extra materials needed beyond the usual surgical set for any facial bone fracture are

1 Stainless steel wire #32 and #25

2 Wire cutter

3 Small orthopedic hand drill and small bit.

4 Small periosteum elevators

5 Box of red dental compound

6 Labial arch wire bars *(optional)* known as Winter arch bars

7 Dental impression trays (optional)

Danger to Airway Severe multiple facial fractures often interefere with breathing Observe the airway carefully! If any strong doubt exists that the patient may obstruct from edema in the floor of the mouth or from a fractured maxilla laying on the tongue, a low tracheotomy must be performed under local anesthesia. By making a low skin collar incision similar to a thyroid exposure only 5 cm. (2 inches) long, the scar is minimum The trachea is easily exposed for a tube to be slipped through the fourth to sixth cartilage rings After the fracture is reduced and edema has subsided in a few days, the tube can be removed with no after effects This precaution will save worry by the surgeon and on occasions will prevent the performance of an emergency tracheotomy under very unfavorable conditions

For the face we must always remember the two criteria for successful treatment (a) Restoration of facial contour for cosmetics (b) Restoration of function the nose for breathing, the mouth for eating, the orbit for holding the eye globe in even position, and the maxilla to retain the maxillary sinus in position, hold the upper jaw and teeth, and retain the floor of the nose

INJURIES TO THE NOSE AREA

The patient has the history of a blow on the nose. Edema is marked within a short time often masking bony deviations Bleeding is profuse from the nostrils The patient s nose is very sensitive and often he does not care to have it palpated

Diagnosis

1 Always ask the patient if his nose was straight before the injury It is embarrassing if not impossible to try to straighten a nose twisted from an old fracture

2 Gently palpate the bony structure and try to determine gross deviation

3 Applicators dipped in a solution of four per cent cocaine mixed in equal amounts with adrenalin will allow for careful cleaning of the nasal cavities and for a clear view of any nasal septum fracture

4 X-rays should be taken—posterior anterior and lateral views

Material Needed

1 Nasal speculum and head mirror
2. Bayonet forceps
3 Heavy Kocher clamp
4 Suction.
5 Applicators.
6 Oxycel.
7 Plaster of paris bandage 7 5 cm (3 inches) width.

Anesthesia (a) One per cent novocain—six drops of adrenalin to ounce This is injected into the nasal bone area through the skin in the region of glabella The infraorbital nerve is blocked off by inserting 3 cc of novocain into each infraorbital canal. The canal is located by palpating the supra orbital notches on the eyebrow A perpendicular line down to the level of the mid alar of the nose will give the point for needle insertion The needle is inserted upwards and inwards hitting the notch easily The patient will usually tell he has pain in his teeth Always withdraw the syringe barrel to avoid entering the infraorbital vessels Word of caution—always hold finger on infraorbital rim to keep from slipping up and hitting the eye while looking for the infraorbital notch

(b) Cocaine four per cent 5 cc. (1¼ drams) mixed with equal amounts of

adrenalin 1 1000 Applicators are dipped in the solution and placed in each nostril, slowly swabbing upwards after the suction removes all blood clots. Once this is done, thin paddles of cotton soaked in the solution can "wall paper" the septum on each side Wait five minutes for the anesthesia to take effect.

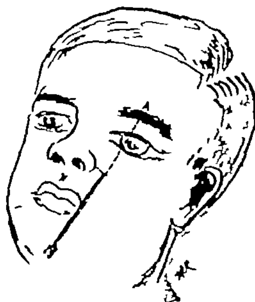


FIG. 1 Diagram of an infraorbital nerve block. The infraorbital nerve is blocked by entering the infraorbital canal with a needle tip The canal is located by palpating the supraorbital notch on the eyebrow (A) and then dropping a perpendicular line down to the level of the lateral border of the alar of nose. At this point, a needle inserted up and inward will usually hit the notch The patient will tell you he has pain in his teeth when the notch is entered. About 3 cc. of novocain are injected in the canal after the syringe barrel is withdrawn to avoid entering the infraorbital vessels. Word of caution—always hold finger on the infraorbital rim to keep from slipping up and hitting the eye globe while looking for the infraorbital notch.

Operation A fresh fracture can easily be reduced by finger pressure For greater force a Kocher clamp can give better leverage by pushing outwards from inside the nasal cavity The fractured nasal bones must be completely loosened from the impaction if recurrence of the deformity is to be avoided from a "greenstick" spring. Should the nasal bones be pulverized or severely comminuted, the bones must be molded into shape



FIG. 2. (A) Typical nasal fracture The boy was hit on his nose by a swinging baseball bat. The bones were pulverized. The septum was crushed and badly displaced. A small laceration was débrided and sutured. The nasal bones were molded with fingers, reconstructing the nasal profile.

The septum must be corrected for deviation. Pressure by instrument will cure most septal fractures If the latter is too twisted or overlapped, the overlapping segments must be excised to prevent airway obstruction.

The nasal cavities are packed with oxycel rather than petrolatum gauze. This helps to prevent hematomas in the septum, bleeding in the nasal cavity

support for the nasal bones, and splinting to keep the septum straight. The nasal bones are kept in the midline by a small plaster cast on the nose. The cast consists of ten layers of plaster gauze cut while dry in the shape of a keystone. The cast is laid, after being wetted, directly on the skin and molded over the nose. When hard, the splint is maintained on the nose by strips of bandage swabbed with collodion and allowed to dry. Aluminum splints lined with rubber or dental compound can serve a similar purpose.



FIG. 2. (B) Sketch. The nasal septum was elevated. Some overlapping cartilage was excised to create a straight airway. A plaster-of-paris cast was applied for ten days to keep the bones in position. The nasal cavities were packed with oxycel.

Postoperative Course: The splint is not changed, adjusted or moved from the nose for ten days and the oxycel packing is not touched for one week. There will be some bloody-serous drainage from the nasal cavities during this time but it is of no great consequence. After ten days the most comminuted nose will keep its shape. The nose interior will be healed by this time. The nasal cavities can then be swabbed with mineral oil on applicators which will clear the mucosa of any crusts.



FIG. 2. (C) Photograph shows the boy two weeks after operation. Aside from edema, the nasal configuration is normal. *The nasal cavities are open.*

FRACTURES THROUGH THE MANDIBLE

The mandible is the second most frequently fractured bone of the face. Being a single bone freely movable and projecting from the face, it is easily fractured when struck directly. The treatment of fractures of the mandible can only become logical if the anatomy of the bone is understood. Since it is maintained in position by muscles, the fractured mandible displaces readily depending on the pull of the supporting muscles.

The mandible consists of three parts the body and two rami The body is formed by the two halves meeting in the midline while the rami begin where the body turns up at the angles Half way up the ramus, the coronoid process turns anteriorly The ramus continues into a neck and then becomes the condyle, making contact with the glenoid fossa above the temporo-mandibular joint In the adult the mandible has just ahead and inside of the maxillary cusps The midline relationship of the mandible is determined by a line drawn from the philtrum to the columella and down between the central incisors

The muscles of the mandible are amongst the strongest in the body The mandible opens by gravity and the general pull of the muscles in the floor of the mouth, mainly the suprahyoid group The main portion of the tem-

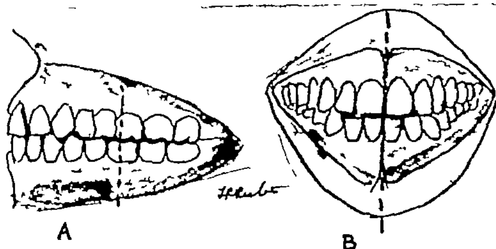


FIG. 3 Diagram illustrating occlusion between the mandible and maxilla. A Illustrates the lateral view Note the relationship of the first molars (dotted line) The mandibular molar's anterior cusp is in advance of the maxillary B Shows a dotted line through the midline between the central incisors.

sixteen teeth which mesh or articulate with a similar number in the maxilla. These teeth are the factors in obtaining a perfect reduction of a fracture When the articulation is restored, the contour and the function of the mandible is also restored

Keynote Get the first molars of the mandible and maxilla to articulate The chewing *surface* of the first molars have five cusps, three buccal and two lingual whereas the second molars have four cusps two buccal (outside) and two lingual (inside) The normal relationship is to have the mandibular cusps poral muscle pulls the mandible upwards but the posterior fibers pull it backwards Some of the *anterior fibers* of the temporal tend to pull the jaw forward with the external *pterygoid muscle* If both external pterygoids function together the jaw juts forward but if only side *contracts*, the mandible will rotate to the opposite side The internal pterygoid pulls the mandible upward, inward, and *slightly forward*, whereas the *masseter* pulls it upward and slightly outward. When fractured, the mandibular components are usually pulled out of line by the strong muscular pull, the

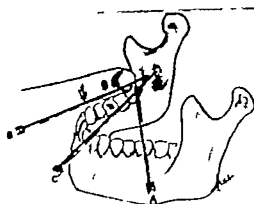


FIG 4 Diagram of an inferior alveolar injection. Sketch shows the mandible with ball of finger between the internal and external oblique lines just posterior to the last molar The needle (A) is inserted with the opposite hand until it hits the ramus at the center of the fingernail the syringe being parallel to the teeth on the side of the injections. The needle is now withdrawn a little shifted to the (B) position and advanced about 6 mm (¼ inch) allowing the tip to slide posteriorly along the ramus. At this position the tip is in the pterygomandibular space between the lingual nerve and the inner surface of the ramus. A few drops are injected to anesthetize the lingual nerve The syringe is now shifted outward so that the needle is in position (C) The tip is advanced a bit further to reach the posterior wall of the mandibular sulcus where the inferior dental nerve enters. Two cc. of novocain are injected

To anesthetize the upper teeth a simple infiltration about the apices of the teeth at the upper buccal sulcus will suffice About 1 cc of solution is placed at each tooth Remember to wait at least ten minutes from the time of injection to the time of wiring.

Treatment *The patient with teeth* The simplest and fastest method to reduce a fracture of the mandible is to splint it against the solid upper teeth. Remembering the relationship of the first molars and observing the midline of the upper and lower jaws the splinting is easily accomplished by wiring the teeth.

There are many methods advocated for wiring. The simplest and very effective one is the Ivy loop method Usually two upper and two lower loops are placed on each side of the fracture site The upper and lower loops are then wired together to bring the teeth into occlusion (intermaxillary wiring)

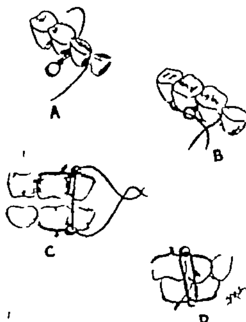


FIG. 5 Diagram illustrates how Ivy loops are placed on teeth No 25 stainless steel wire is used. (A) Small loop is first made and twisted with both ends inserted from the buccal (outer surface) towards the lingual side (inner surface) of the teeth In (B) the strands are twisted around two teeth with one of the strands coming through the eye of the loop (C) Illustrates how the loop in the upper and a loop in the lower teeth are joined together with an intermaxillary wire by passing this wire through the eyes of each loop. (D) Illustrates final tightening of the wires. It is advisable to make sure that the twisted wire ends are turned inwards to avoid rubbing against the lips.

Caution. If there was a history of unconsciousness or of constant vomiting have a scissors always tied on the patient's bedside If the patient vomits

direction being determined by the amount and type of muscle being attached to the shorter fragment.

Diagnosis. There is a history of a blow on the mandible Swelling may often be present The patient cannot open his mouth readily or if he can, he has pain and a feeling of abnormal occlusion of his teeth Certain blows often cause typical fractures, an example being a blow on the midline of the chin producing a fracture in the region of the symphysis and frequently both condyles A blow to the body of the mandible on one side causes a fracture at the site of blow plus one at the opposite ramus

Physical Examination This reveals

1 Abnormal occlusion Always check relationship of first molars and other teeth

2 Often an inability to open the mouth is present usually more marked in condyle fractures

3 Abnormal motion at suspected fracture site

4 If no fracture site is apparent and pain is felt at the temporomandibular joints, associated with difficulty in opening mouth, rule out dislocation as well as condyle fracture

5 X rays are needed—laterals and posterior anterior views.

6 Always ask patient if his teeth were normal before the injury Abnormal teeth relationship (malocclusion) may have existed before and this may make it impossible to judge the correct molar *position.*

7 Severely comminuted fractures at the angle may tear big vessels in the neck with resulting hemorrhage into the floor of the mouth. Observe constantly for pressure on the trachea and breathing obstruction.

8 Fracture of the edentulous (no teeth) patient s mandible is easily diagnosed because of motion at site of fracture

Materials Needed

(a) For closed reduction—intraoral or intermaxillary wiring
  1 #25 stainless steel wire
  2 Peon clamp or a needle holder
  3 Wire cutter
  4 Dental impression compound.
(b) For open reduction
  1 #25 gauge stainless steel wire.
  2 Small hand drill and small bits
  3 Periosteum elevator
  4 Complete surgical set

Anesthesia For most patients the combination of morphine and scopolamine will give enough sedation to allow any wiring about the teeth. *Caution* no morphine if patient had a brain injury For a very sensitive patient the mandibular branch of the fifth nerve can be blocked as it enters the inferior dental canal This can be performed in the following manner

Technic of Inferior Alveolar Nerve Injection The needle used is a 37 mm (1½ inch) #21 gauge on a 5 cc syringe containing two per cent novocain with eight drops of adrenalin to the ounce The surgeon stands in front of the patient. The left forefinger is placed in the mouth onto the anterior border of the ramus The finger is passed a bit medially until a ridge, the external oblique line is felt and then is moved a bit posterior to a depression With the ball of the finger in the depression, the finger is turned out externally the radial side of the finger being parallel with the occlusal surfaces of the lower molars (Fig. 4)

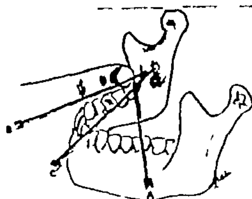


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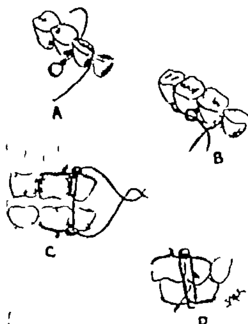


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Caution. If there was a history of unconsciousness or of constant vomiting, have a scissors always tied on the patient's bedside. If the patient vomits

and has to have his mouth opened in a hurry the nurse can cut the wires to avoid respiratory obstruction If the fracture is several days old and the fragments cannot be brought into occlusion



A.

Fig. 6 (A to C) Illustrating close ups of Ivy loops in the mouth. Wires used as intermaxillary fixation.



B

Fig 6. (B) Elastics used as intermaxillary fixation.

by the intermaxillary wires orthodontic elastic bands can be placed on the Ivy loops and gradually the elastic pull will bring the teeth into occlusion Once occlusion is established the intermaxillary wiring can be used.

In hospitals where many fractures are treated, the dentist will usually handle the intraoral wiring. A convenient wiring method is the use of the Winter labial arch bar This splint can be wired to many upper and lower teeth, distributing the stress of wiring on all teeth



C.

Fig. 6. (C) The use of a Winters labial arch bar when there is displacement The arch bar is cut so that both portions of the mandible can be fastened individually to a bar placed on the upper teeth.

Postoperative Care. Feeding is a problem with the teeth wired. The average patient loses about 9 kg (20 lb) if the diet is not carefully observed A high caloric, high vitamin, high protein fluid diet is prepared and given to the patient every two hours Pureed foods may be used too In most cases the fluids can be swished into the mouth



FIG. 7 Series of roentgenograms illustrate several methods in the treatment of mandibular fractures. Roentgenogram A shows a fracture present at the left angle with one tooth in the line of fracture. The other fracture is through the region of the bicuspid. Because of the strong muscle pull and because of the lack of teeth to occlude against, these fragments are pulled out of position by the internal pterygoid and masseter muscles. Roentgenogram B shows an osseous wire placed at the left angle with two small loops around the teeth to keep them in position. The fracture on the right side has been temporarily reduced. This fracture site can be seen more readily in roentgenogram C. Roentgenogram D shows two labial arch wires placed on the upper and lower teeth to bring teeth in occlusion. A comment must be made about the tooth in the line of the fracture of the left angle. It is our policy to leave teeth in the line of fractures unless the tooth is broken off, until complete healing has taken place. If the tooth is nonviable, it is then carefully removed at a later date. The advent of antibiotics has removed the necessity for removing every tooth in the line of fracture because of the danger of infection.

through the teeth behind the molars and often through missing teeth. After each feeding he must carefully rinse his mouth with a solution composed of saline mixed half with peroxide A final rinse with saline will complete the toilet. Teeth must be carefully brushed twice a day

After four weeks the intermaxillary wires are removed and the patient is given a test of motion If all is well and the occlusion is correct, the rest of the wires are removed in a few days

SPECIAL MANDIBULAR FRACTURE PROBLEMS

Midline Fractures. This fracture is very difficult to heal Possibly the midline is avascular since the end arteries meet here and the pull of the infra mandibular muscles is the strongest Our policy has been to do a direct osseous wiring as well as the intermaxillary oral wiring.

DESCRIPTION OF OPERATION A skin incision is made under the chin exposing the muscles of the floor of the mouth The inferior border of the mandible is brought into view by skin retraction and cutting through the platysma The fracture site is located and the periosteum is freed anteriorly and posteriorly Two drill holes are made on each side of the midline using the precautions of placing guards to avoid deep penetration of the soft tissues when the drill point comes through the hard bone Number 25 wires are passed through the holes and tightened to bring the fractured bone into line (*Caution*—make sure the ends of the wires are tucked in to avoid sharp irritation on the skin when closure is complete) The wound is closed in layers When the operation is completed the teeth are then closed in occlusion by the intramaxillary wires The osseous wires are rarely removed

FRACTURES AT THE ANGLE OF THE JAW

These fractures are common. Usually the fracture site is through the second or third molars If teeth are present they may hold the posterior fragment and the ramus in good position and the use of antibiotics, especially penicillin will tend to give ample protection against tooth infection in that region. The usual intermaxillary wiring is done and only after complete healing is the tooth in line of fracture removed by the dentist.

If the tooth becomes infected or the root is broken off the tooth has to be removed The result is an immediate pulling up of the posterior fragment by the internal pytergoid and part of the masseter muscles The pterygoid tends to pull the ramus inward, forward and upward. The patient cannot bite downward because of the elevated posterior fragment. In such cases the simplest and only accurate method of choice is a direct osseous wiring. As in the midline fracture, the fracture site is uncovered by making a skin incision this time inferior to the angle Make certain the incision is parallel with the inferior border of the mandible and low enough to be in the neck rather than the cheek (Most important for cosmetic reasons) Wires are placed in bony fragments after the holes are drilled. The teeth may be used to support the fracture site by the usual inter maxillary wiring.

Some cases can be treated by the closed method This is particularly true if the posterior fragment on the mandibular body is long and the upper molar teeth are present. The usual intermaxillary wiring is done but before

the intraoral wires are fixed to bring the teeth in occlusion a piece of dental impression compound is molded over the upriding mandibular alveolar ridge The upper teeth will press down on the compound which in turn will force the fragment back into position. Although this method is not accurate, circumstances may make this simple procedure desirable

FRACTURES THROUGH THE CONDYLE OR CORONOID PROCESS

Very few fractures through the condyle or coronoid process need special treatment. Our policy has been to use intermaxillary wiring for ten days only Rarely does the condyle have to be removed or wired directly The only indication is fracture with marked displacement.



FIG. 8. Roentgenograms illustrating treatment of the edentulous mandible. A Fractures in two areas.

FRACTURES OF THE EDENTULOUS MANDIBLE

If the fracture is through the body the toothless mandibular bone can be splinted by wiring to his false teeth (acting as a splint) to the mandible in a single procedure known as a circumferential wiring If the lower false teeth are missing a simple splint made of dental impression compound can be molded over the lower gums and substituted for false teeth



FIG. 8 B Illustrates direct wiring placed around each fracture site.

Procedure: Three 1 cm. incisions are made through the skin in the lower mandibular region, one about the midline and the others about the region where the first molar teeth would be A large curved cutting edge needle threaded with #25 wire is passed through the skin incision and into the mouth coming out just inside of the alveolar ridge (lingual) The other end of the wire is passed on in a similar manner this time coming through into the mouth just external to the mandible (buccal) The wires are pulled up tight and twisted over the denture (false teeth) so that the fractured mandible is held in place against the splint. The lower false teeth can then be wired to the upper teeth for better fixation.



FIG. 8 C Illustrates the use of circumferential wiring, using a dental compound splint to reinforce the wiring

If the fracture site is in the midline or near the angle we usually do the direct osseous wiring in addition at these sites.

DISLOCATION OF THE MANDIBLE

Dislocation of the mandible can occur when a blow is delivered to the chin while the mouth is open. The anterior dislocation is the commonest type seen Upward dislocation through the roof of the glenoid fossa is very rare and occurs only when a very severe blow is struck on the chin The mandible usually shatters before it goes into the skull. The same is true for backward dislocation into the auditory canal

Mechanism The mouth being open, the condyle tends to slip over the eminentia articularis of the joint. The interarticular fibro cartilage is drawn forward by the external pterygoid muscle while the masseter and internal ptery

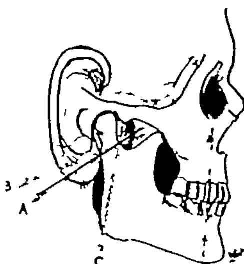


FIG. 9 Diagram of an external maxillary block. Sketch shows the relationship of the temporomandibular joint, the zygoma the notch between the condyle and the coronoid process, and lastly the perpendicular plate of the pterygoid. The ear is sketched on to show external anatomical position.

After determining the notch anterior to the tragus and just inferior to the zygoma, a drop of novocain is placed in the skin over the notch. A 7.5 cm. (3 inches) #20 gauge needle (A) is stuck at right angle to the ramus through the middle of the notch until the pterygoid plate is hit about 2½ inches deep. The needle is withdrawn slowly for about 6 mm. (¼ inch) and then pointed anteriorly at a 70 angle (B) Then it is advanced again almost to the 7.5 cm. (3 inches) mark This will place the needle tip at the opening of the foramin rotundum where the maxillary branch of the fifth nerve emerges from the cranium. About 5 cc of novocain are deposited here and then as the needle is slowly withdrawn, more novocain is injected until the skin is reached.

If the mandibular branch block is desired, the needle is advanced in similar manner posteriorly until the foramin ovale is reached, position (C)

The line I II shows the vertical line relationship between the supraorbital notch the infraorbital foramin, the canine tooth, and the mental foramin.

goid muscles pull the mandible up into the tight position of an open bite keeping the mandible in its abnormal new position.

Diagnosis of Mandibular Dislocation

1 Protruding bite with inability to close mouth.

2 Pain at joints.

3 Palpation in front of the ear may disclose a hollow space

4 Intraorally the ramus can be felt to be forward

5 A unilateral dislocation will rotate the chin to the other side

Treatment Most often a deep general anesthetic is needed for good relaxation The surgeon stands in front of the patient, and inserts his thumbs, well padded, over the molars on both sides. Pressure is made downwards with the thumbs while the rest of the fingers tilt the chin upwards This motion will depress the condyle enough to slip downward back under the articular eminence The muscles will then keep the jaw in position A simple headchin bandage for several days will allow the capsule to heal.

FRACTURES IN REGION OF ZYGOMATIC ARCH

There is a history of a severe blow on the side of face with a blunt object. Within a short period, marked swelling obliterates all landmarks If no treatment is instituted the edema will recede with a depression over the zygomatic arch.

Diagnosis·

1 Marked edema over the zygomatic arch.

2 In late cases a depression can be felt in the region.

3 Severe fracture will depress fragments to degree of interfering with mandibular function by touching the coronoid process

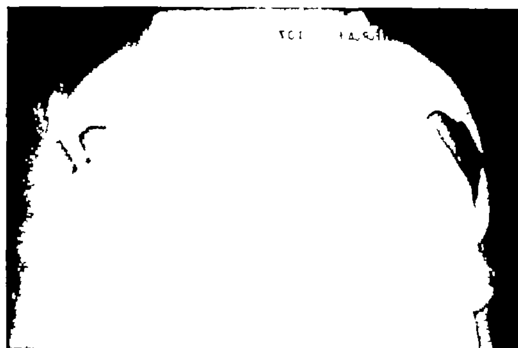
4 X rays for fracture using vertex-mentum technic (Taylor position)

Materials Needed for the Treatment Usual surgical set and heavy Kocher clamps or genitourinary sounds

Anesthesia In early cases up to one week, local regional fifth nerve block and infiltration anesthesia with one per cent novocain is usually sufficient. In late cases a general anesthetic may be necessary

For the local block the patient opens and closes the mouth, while the surgeon palpates in front of the tragus for the notch between the condyle and the coronoid process The notch is usually just inferior to the zygomatic arch and a finger's breadth anterior to the tragus A drop of novocain is placed over the notch in the skin This is followed by a 7.5 cm (3 inch) #20 gauge needle inserted straight in at right angles to the mandible ramus and in the middle of the notch. The needle will hit the perpendicular plate of the pterygoid at about 6.3 cm. (2½ inches) deep The needle is withdrawn slowly for about 6 mm. (¼ inch) and pointed anteriorly at a 20 degree angle It is then advanced again almost to the 7.5 cm mark. This will place the needle tip at the opening of the foramen rotundum through which the second branch of the fifth nerve emerges. About 5 cc. of novocain are deposited in the area. The needle is slowly withdrawn, injecting until the point is out of the skin. Five minutes must pass before proceeding with the surgery While waiting, it is advisable to use local infiltration into the fracture site to ensure complete anesthesia.

Treatment The treatment of choice is the Gillies operation. The temporal



A



B

Fig. 10 Roentgenograms illustrating fracture of the zygoma bone This view is the mentum-vertex position. A is the preoperative while B is the postoperative views of the fracture

area is shaved The superficial temporal artery is palpated anterior to the auricle and is avoided in the skin incision which is made anterior to it at the level of the top of the auricle The incision is about 2.5 cm (1 inch) long and is carried down to the temporal fascia The latter is a glistening sheath which covers the temporal muscle extending from the skull down under the zygoma to the coronoid process of the mandible A small incision is made through this fascial sheath and a Kocher clamp is easily dropped on the external surface of the temporal muscle downward until it reaches the depressed zygoma pressing on the sheath Upward and outward pressure will push the zygomatic arch back in position, which is usually maintained with no further support.

If the fracture is old, a small pad on the scalp under the elevator can give a better fulcrum for more leverage By comparing the opposite side complete reduction should be obtained Postoperative x rays can confirm the reduction



FIG. 10C Diagram A shows the elevator coming down on the fascia covering the temporalis muscle and going under the fractured zygoma. B shows the incision in relation to the ear

FRACTURES IN REGION OF THE MALAR BONES

Malar bone fractures are often associated with fractures of the nose, maxilla, or zygoma.

The patient gives a history of a blow to the face in the region of the cheek bone Edema and ecchymosis follow quickly masking any deformity

The malar makes up the cheekbone and by being in contact with the zygoma, frontal maxilla and nasal bones keystones and shapes the contour of the face It makes up most of the infraorbital support of the eyeball and is the lateral and anterior wall of the maxillary sinus Being a heavy bone supported by thin projecting arms fastened to the above mentioned contiguous bones it is frequently fractured downward and inward through the maxillary sinus when a strong blow hits the bone from above *The commonest sites of fracture are at* the infraorbital rim the junction of the frontal-malar projections, and at the contact with the zygomatic arch. Rarely is the body itself fractured

Injury to the malar can interfere with vision by dropping the floor of the orbit and changing the eyeball balance with the opposite eye When this occurs the infraorbital nerve which runs in the floor of the orbit, is crushed. The maxillary sinus is obstructed by the body being impacted in the cavity

Diagnosis. 1 Marked edema and ecchymosis over the malar and lower eye lid are noted. Even with an underlying depression deformity the injured side looks larger than the normal side The depression deformity is rarely seen be-

fore two weeks after the swelling has diminished.

2 Palpation along the orbital rim can often locate the fracture site

3 A finger placed on the malar prominences on both sides can determine the cheekbone to be lower on the fractured side

4 Loss of sensation from the crushed infraorbital nerve can be determined by stroking the cheeks and the side of the nose and lower eyelid with a cotton applicator

5 In severe depressions the floor of the orbit is displaced downward with resulting diplopia.

6 X rays taken in the Waters position will show the infraorbital areas and the maxillary sinus A word of caution must be given. The x rays must be clear and both sides compared. Commonly the malar body pivots down and in on the fracture site rotating at the malar frontal junction and at the medial side of the infraorbital rim On x ray studies therefore there are superimposed shadows with no break being noticed Only by observing the cloudy maxillary sinus, feeling the depressed cheekbone, and noting the change of infraorbital skin sensation can the decision to operate be made

Treatment. Materials needed

1 Usual surgical set.
2 Two heavy urethral sounds
3 Periosteum elevators
4 Suction.
5 #25 gauge stainless steel wire.
6 Small hand drill and small bits.

Anesthesia The anesthesia is often dependent on the severity of the fracture as well as the time elapsing from the moment of injury to surgery For extensive reductions and for those cases more than a week old, endotracheal anesthesia is best. However for most malar fractures local block anesthesia is adequate After the usual local preparation is made a one per cent novocain block is given to the second or maxillary division of the fifth nerve by the external route as described under the chapter of zygomatic fractures Local skin or mucosal infiltration is given depending upon the method of surgery chosen

Surgery For a fracture of the lateral portion of the malar involving the zygomatic prominence, an incision through the temporal region as described under the zygomatic discussion will serve to reduce the fracture



Fig. 11 Sketch showing different methods of repairing the malar bone fractures. A illustrates direct wiring at the infraorbital ridge and at the frontal malar junction. B shows the elevation of the lateral portion of the malar through the Gillies approach. C shows the approach through the maxillary sinus.

For a fracture involving the body which has been depressed by rotation and pivoting at the infraorbital ridge and the malar zygomatic junction a successful reduction can be obtained through the maxillary sinus approach. An external block will anesthetize the maxillary branch of the fifth nerve

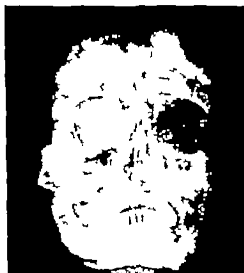
Novocain is injected into the upper buccal sulcus of the affected side An incision is made in the vault of the sulcus in the region of the bicuspid teeth exposing the anterior wall of the maxillary sinus The muscles are lifted from the wall by a small periosteum elevator disclosing in most cases a hole in the fragmented wall The latter is caused by the displaced body of the malar Some of the bony fragments are removed to allow suction into the maxillary sinus and to pass a large urethral sound or large Kocher clamps into the cavity By pressing upward and outward, the body of the malar can be returned to position. If corrected early the reduction should take but a few moments Only by comparing the position of the malar prominences can the reduction be judged adequately Since the malar is heavy and there is a tendency towards dropping, the sinus is packed with iodoform gauze packing saturated with tincture of benzoin The packing is carefully tucked in all crevices to hold the malar in its position One end is allowed to protrude through the incision of the buccal sulcus The wound is not sutured The packing is carefully withdrawn in ten days

Many surgeons advocate making a window through the inferior meatus of the nose and passing the end of the packing through the nose instead of the buccal sulcus to the mouth. We do not



A

Fig. 12. Description of a typical malar bone fracture. A The typical flat face and lowered cheekbone.



B



C

Fig. 12B and C. Roentgenograms show at (A) the separation of the frontomalar junction, at (B) the depressed infraorbital ridge, and at (C) the inward fracture of the body of the malar off from the zygoma.

use the window often, since a fistula is rare Another reason for the window is the possibility of a sinus infection. Seldom is infection a residual result if no loose bone fragments are left in the sinus and if penicillin is liberally used. The advent of antibiotics has certainly changed the morbidity of facial fractures

For those cases where the infraorbital ridge and the floor of the orbit are depressed, we have found direct bone wiring after open reduction to be the most accurate method of repair



D

FIG. 12D Because of the type of fracture, the method of reduction selected was the maxillary sinus approach. The sinus was entered as illustrated in 12D Upward and outward pressure was made until the body of the malar was elevated to the normal position. The sinus was packed with iodoform gauze saturated with tincture benzoin. The free end of the packing was brought out at the opening into the mouth The packing was removed in ten days.

The depressed orbital floor can often be felt. An incision is made through the skin to the orbital rim the incision following a wrinkle to avoid unnecessary scarring Once the fracture site is uncovered, a small periosteum elevator is used to lift the periosteum from the orbital floor and the anterior wall Another incision is made through the skin (also in a wrinkle line) at the junction of the frontal-malar bones where the displacement is usually great. The fracture sites are carefully manipulated with the elevator until the rim is restored to the



E



F

FIG. 1_ E and F show the postoperative result and postoperative roentgenogram

normal continuity Small holes are carefully drilled on each side of the fracture sites and #25 stainless steel wire is passed through tightening them when the bones are aligned Caution must be used to avoid injury to the eye ball while drilling holes A small hand drill is safer than a motor drill A metal protector like a knife handle should guard against a sudden jerk through the bone into the globe If more than one bony fragment is present each portion must be wired together All wire ends are carefully bent downwards to avoid sticking into the skin or orbit. The wound is closed in layers using fine 6-0 black silk as mattress sutures to evert the skin edges A very soft pressure dressing will keep some of the edema of the eyelids down.

A severe fracture may be difficult to reduce and the maxillary sinus approach may have to be used in addition to elevating the body of the malar

The postoperative course is usually uneventful If the sinus packing is re moved in ten days the bones will be found to be healed sufficiently to maintain their position The stainless steel bone sutures remain The silk skin su tures come out by the fourth day

INJURIES TO THE REGION OF THE MIDFACE INVOLVING THE MAXILLA

The automobile has made this fracture commonplace Rarely is the maxilla fractured alone but most often has associated fractures, the nasal bones as well as intracranial injuries

Mechanism of the Fracture· The history given is of a direct blow to the middle of the face the nose usually re ceiving the brunt of the force. The



FIG. 13 Photograph illustrates how a severely fractured maxilla can fall and rest on the tongue causing obstruction to breathing. A tracheotomy must be considered early If it is impossible to reposition the maxilla at once. Arrow points to tongue.

maxilla is driven back and breaks across at the level of the nose and the lower malar region The fracture line often forms a triangle the apex being up at the nasal bones. The entire palate can separate from the rest of the maxilla and, being driven backwards, can block breathing. The fracture site might be in the midline separating two halves of the maxilla, one side only being driven back and downward.

Physical Findings· Immediately following the trauma marked edema occurs along the midface. A severe fracture will cause great difficulty when the palate lays on the tongue When teeth are present, they will be found to be out of occlusion. Commonly there is leakage of cerebral spinal fluid from a tear through the meninges of the cribiform plate

In mild cases with no displacement, edema of the midface and movement of the maxilla by the examining hand may be the only findings, although some patients may complain of a numbness of the upper teeth. The diagnosis of a fractured maxilla is frequently made by physical signs

X rays rarely show a fracture with little displacement. A severely displaced fracture may best be seen by a true lateral and posterior anterior plates A Waters position, the same view taken for the malar bones, may help Negative x-rays are not indicative that fracture is not present.

Treatment Early treatment is imperative The special relationship of the middle part of the face is maintained by the maxilla Corrective fixation of the displaced bone must be done to relieve respiratory obstruction, to allow the dural tear at the cribiform plate to heal and stop the cerebral spinal fluid leakage and to restore occlusion.

MATERIALS NEEDED

1 Stainless steel wire #25
2 Wire cutter
3 Dental compound.
4 Dental impression tray (not imperative)
5 Regular surgical set.

ANESTHESIA If treated early most fractures can be reduced with the aid of a local block of the maxillary division of the fifth nerve (see description under discussion on malar fractures) With severe obstruction to breathing, a low tracheotomy may be performed and a light general anesthetic given through the tracheotomy tube For those cases where general anesthesia is indicated and tracheotomy is not needed, an endotracheal tube must be inserted before treatment is started If the patient has a cerebral concussion, general anesthesia is contraindicated.

METHODS OF TREATMENT The mandible with teeth, if not fractured, is an excellent splint for holding the fractured maxilla in position If the molars are brought into occlusion by manually repositioning the maxilla, two Ivy loops on each side (as described in treatment of mandibular fractures) will maintain the normal relationship If only one side of the maxilla is fractured, a labial arch bar (Winter arch) placed across the teeth on both sides of the maxilla will hold the fractured side on the solid half.

Wiring is maintained for fifteen days the maxilla usually becoming fixed by then.

An aid in determining vertical height in a severely comminuted fractured maxilla where a few teeth are present is to close the lips gently and then open them slightly The teeth should be seen just touching through the mouth slit.

Edema and fractured teeth limit this aid

THE MAXILLA WITH NO TEETH The treatment becomes complicated when no teeth are present The teeth help determine just where the maxilla should be placed in relation to the mandible Without them it is difficult to determine the vertical height of the face if the maxilla is severely fractured The maxilla usually rests on the tongue and has to be raised up and supported until healed. There are several likely methods of treatment The first can be simple

Artificial teeth, plates or dentures should be found after an accident, since they can serve as occlusion splints to hold the fractured maxilla in correct position. If broken, they must be repaired immediately with quick setting plastic and used To keep the splints from moving they can be wired directly to the maxilla by drilling several small holes through the alveolar ridge anteriorly and laterally and passing #25 stainless steel wire through to wrap around the maxillary denture The lower mandibular denture is fastened to the mandible by the circumferential wiring technic as described in mandibular fractures The upper and lower dentures are then wired together in occlusion.

When no dentures can be found, another method of treatment is used. If teeth are present on the mandible dental compound is molded in warm water to form a soft mass roughly horseshoe in shape and about 2.5 cm (1 inch) thick. The maxilla is moved forward to what the surgeon thinks is the correct position The mushy compound is placed on the maxillary alveolar ridge to lay between the mandible and the maxilla. The mandible is closed tightly When the compound is hardened it forms a good fitting splint The mouth is opened carefully and the splint is removed. It is trimmed for rough edges and a hole is drilled in the center to allow a tube to pass through for food A head bandage will help hold the mandible closed after the splint is returned to the mouth and the occlusion reformed This type of splint is known as a "mush" splint. A similar procedure can be used when



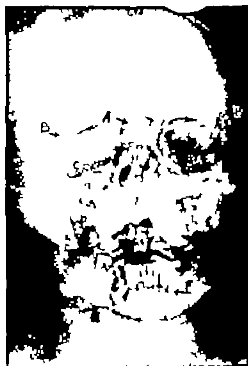
A

FIG. 14 A series of photographs illustrating multiple facial bone fractures. The patient's face hit his dashboard when the auto struck a telephone pole Photo A shows him two hours after injury The patient was conscious despite his severe multiple fractures. He suffered pulverized nasal bones, bilateral fractures of the malar bones with severe displacement, complete fracture of the maxilla with this bone resting on his tongue, obstructing his breathing, and compound comminuted fractures of his mandible in several places. Because of obstruction to his airway an immediate tracheotomy was done. Through this tube after neurosurgical clearance, a light ether anesthetic was administered. A slow continuous blood transfusion was given during the operation.

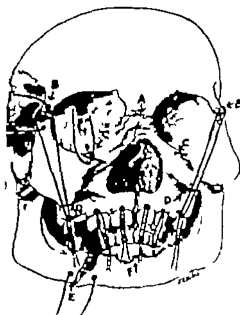
both the maxilla and mandible have no teeth.

A complicating problem to the displaced maxillary fracture is a severe brain injury The mouth must be kept open for possible vomiting and salivation In such cases the procedure of choice is a temporary lifting of the displaced maxilla off the tongue by a dental upper impression tray filled with dental compound This tray has a Kirchner wire driven through the tray horizontally so as to give two projections on each side of the mouth The tray is molded to the upper teeth or alveolar ridge and when hardened the tray is lifted by using a bandage headcap about the projecting Kirchner wires This takes the maxilla off the tongue It must be stated that this procedure is but a temporary one and when the danger of the head injury is over the mouth has to be closed in normal or near normal occlusion.

A rapid stabilization is the use of two Kirchner wires driven directly horizontally through the face at different angles



B



C

FIG. 14B Preoperative roentgenogram.

FIG. 14C. Photo of x-rays shows the fracture sites. A is the pulverized nasal bones. B are the bilateral fractured malar bones with separation at the malar frontal junctions and depression and rotation inward at the infraorbital ridges C. D illustrates the fractured maxilla depressed and E and F show the mandibular fractures. The sketch illustrates how holes were placed in the supraorbital ridges and wiring done to unite the bilateral malar frontal junctures. From these holes wires were threaded through the soft tissues of the face to emerge at the buccal sulcus under the upper lip At C the infraorbital ridges were wired into position, repositing the malar bones. At F the mandible was restored to one piece by direct wiring Wires were placed about the remaining teeth and these were fastened to bring the mandible into occlusion with the maxilla. By pulling up the wires from the supraorbital ridge to the remaining molars on the maxilla, the latter was raised off the tongue into the normal spacial relationship





D E

FIG. 14D and E. Postoperative roentgenograms.

to hold the fragments However direct or partially direct wiring of the displaced maxilla can give more accurate and quicker results The maxilla is suspended from the solid part of the face usually the infraorbital sinus by stainless steel wires The technic is quite simple. The infraorbital rims are uncovered in the lateral third by cutting through skin along wrinkle lines The periosteum is elevated and small drill holes are made through the rims, taking the precautions mentioned in malar bone wiring A #25 stainless steel wire is threaded through the hole on each rim and then passed down through the facial muscles close to the maxilla and out through the buccal sulcus into the mouth. A large straight Hagedorn needle is very effective for this procedure The wound of the infraorbital region is closed in layers and the skin finally is closed with 6-0 black silk. The wires coming through the buccal sulcus are fastened to an upper denture or splint. By pulling up on the wires and tightening, the maxilla can be elevated to its normal position. The mandible can then be wired to the maxillary splint, drawing the latter forward or backward for better maxillary occlusion.

An accompanying fracture of the mandible will complicate treatment still further The treatment of this type of fracture will be discussed under multiple facial bone fractures

MULTIPLE FACIAL BONE FRACTURES

This is the common injury to a passenger in automobile accidents when the face hits hard on the dashboard.

The nose is usually pulverized, the maxilla falls on to the tongue and the

mandible may have one or more fractures

Edema masks all findings The patient usually has multiple facial lacerations and head injuries to complicate matters The surgeon must be aware of all the methods of treatment for all the facial bones and must be ready to use one or more methods as needed



F

FIG. 14F Photograph of the patient four months after the accident There are no residual deformities.

The prime consideration is an air way A tracheotomy should be performed if respiratory dangers are serious Do it early before edema of the floor of the mouth obstructs breathing.

The direct wiring is the most accurate and quickest method for reduction. Wires suspended from the infraorbital or lateral orbital rims as described in the previous discussion on the maxilla can be dropped into the mouth to be fastened to a labial arch bar or splints.

If the infraorbital rim is also fractured downward when the malar is depressed, direct wiring for the rim can hold that bone together The fractured nose can be held in position with a plaster cast after the bones are molded to form a good bridge A fractured edentulous mandible accompanying this multiple holocaust can have a direct wiring and a circumferential wiring to make it solid enough to splint the maxilla.

It takes all the surgeon's skill to treat one of these fractures A rounded knowledge of facial bone fractures will not only save a life but will prevent horrible malformities to plague the unfortunate victims In this mechanical age every surgeon must have this knowledge at his fingertips

MERVIN C MYERSON M D

5

The Control of Hemorrhage from the Nose and Throat

HEMORRHAGE from the nose and throat occurs so frequently that an understand ing of its control is of importance to every physician Control of such bleeding is dependent upon an understanding of its causes

Hemorrhage from the nose, epistaxis is so common that many cases never reach the doctor In ninety-eight per cent of cases nose bleeds can be localized to the antero-inferior portion of the nasal septum These veins comprise the Kiesselbach plexus which is localized to Little s area. In hospital practice the incidence of bleeding from this re gion is relatively less frequent. Epistaxis may occur at any age, though it is rarely seen below the two year level

The etiology of nose bleed may be divided into two main groups those which are produced by local or immedi ate causes and those which are due to systemic or constitutional factors

LOCAL CAUSES

1 Local nasal condition
   a. Septal deformities.
   b *Atrophic rhinitis.*
2. Trauma
   a. Self-induced
      (1) Forceful blowing, sneezing, nose picking.
      (2) Continued localized contact with vasoconstrictors.
   b External or accidental
      (1) Surgery
      (2) Accidents.
      (3) Exposure to chemical fumes.
3 Ulcerations
      (1) Nose picking.
      (2) Vasoconstrictors.
      (3) Chemical fumes.
      (4) Atrophic rhinitis.
4 Foreign bodies.
5 Neoplasms.
6. Congenital telangiectasia.

SYSTEMIC CAUSES

1 Hypertension.
2. Congestive heart disease
3 Abnormal conditions of the blood.
4 Chemical poisoning.
5 Reaction to high altitude
6. Vicarious menstruation.
7 Vitamin C deficiency
8 Tuberculosis—local ulceration.
9 Syphilis—local ulceration.
10. Early stage of infections with high fever

A majority of nose bleeds result di rectly from angulation or concavity of the antero-inferior portion of the nasal septum where the mucous membrane is abnormally thin. The drying effect of cold or hot air or wind causes a crack or break in the continuity of the membrane, and bleeding. This part of the septum is more vulnerable to trauma, whether it be the excessive pressure of a sneeze or strong blowing of the nose

or picking with the finger Practically all nose bleeds in young children are due to nose picking, despite the frequent protests to the contrary of both parent and child The membranes of atrophic rhinitis are excessively dry because of lack of proper mucous secretion therefore the frequent bleeding in such cases

An increasingly more frequent cause of anterior septal ulceration and bleeding is the continued use of vasoconstrictors applied to the same part of the septum over a period of time. Occasionally one encounters extensive ulceration or perforations as a result of exposure to acid fumes Lacerations of the nasal mucous membranes are responsible for many of the hemorrhages resulting from automobile accidents Bleeding may also occur after surgery of the nasal structures or sinuses

Tumors both benign and malignant, are responsible for nasal hemorrhage Among the benign growths those which cause bleeding most frequently are the angioma, fibroma and plasmocytoma. Hemorrhage is a frequent complication of malignant tumors in the nasal structures A single severe hemorrhage complicating such a growth means that a large vessel is eroded. It also indicates that more hemorrhages may be expected. Since a subsequent hemorrhage might prove fatal, ligation of the carotid artery which nourishes the involved area should be performed.

Foreign bodies which remain in the nose for more than a few hours may cause ulceration and bleeding.

A telangiectatic process which is hereditary and has been described variously as Osler's disease Rendu Weber disease and pseudohemophilia, is the frequent cause of repeated nasal hemorrhages The same lesions occur on the skin and the mucous membranes of the mouth Death has been known to occur in a small percentage of such cases because of the extent of the process and the difficulty encountered in controlling the bleeding Tuberculous and luetic ulcerations are less common causes of nose bleed

Foremost among the systemic causes of nasal hemorrhage is hypertension The possibility of this condition must be kept in mind whenever an adult is seen with a nose bleed Poorly compensated heart disease can cause epistaxis Disturbances of the blood such as purpura, leukemia, hemophilia, and certain anemias are responsible for nose bleed Vitamin C deficiency is an occasional cause High fever at the beginning of severe infections such as typhoid fever malaria, pneumonia and some of the exanthemata favors nose bleed

High altitude is another cause of epistaxis The higher up one goes the less is the pressure of the surrounding atmosphere on his tissues. A point is reached where the atmospheric pressure is not sufficient to prevent the rupture of a superficially placed septal vessel

Treatment

The treatment of epistaxis is simple in a great majority of cases Since most bleeding originates from the anterior portion of the septum, pressure can be exerted easily upon this area by means of a cotton tampon to stop it. If a superficial vessel can be seen it should be destroyed by the use of nitric, trichoracetic, or chromic acid, after local anesthesia has been induced with pontocain or cocaine hydrochloride solution Only a small application of the acid is

needed the size of the area cauterized should not be greater than the site of the exposed vessel

When bleeding is due to the cracking or ulceration of an atrophic membrane directly over an angulation or a convex surface frequent application of a lubricant, preferably white petrolatum should be made to the area The patient should be instructed to carry a small tube of white petrolatum and make applications with the ball of his little finger every hour or half hour for the first two or three days, then three or four times a day The frequent application of a lubricant, which is so badly needed, is the only way to bring the membrane back to health. Immediately after cauterization of the nasal mucous membrane, a tampon of cotton saturated in oil, should be left in contact with the treated area for a few hours A suitable nasal lubricant should be used for the next ten days or two weeks to prevent a recurrence of bleeding

Although bleeding due to a vitamin C deficiency is less frequently encountered than formerly such a possibility must not be overlooked.

For bleeding which complicates surgery or accidental injury the nose should be packed with a 12 mm (½ inch) gauze strip saturated in melted white petrolatum Yellow petrolatum should not be used since it contains resin which causes the gauze to become rigid and makes it adhere to the wound. Difficult removal favors recurrence of bleeding Packing may be left in the nose two or three days or even longer if sulfonamides or antibiotics are administered

Automobile accidents account for a majority of intranasal lacerations. These may be associated with extensive fractures of the bones of the face Severe hemorrhage occurs in most cases It is important to repair lacerations by suture, if possible and to replace displaced bony fragments whenever conditions permit. Hemorrhage can be controlled by packing. At times it becomes necessary to leave the packing in for as long as seven days or more If tried and dependable chemotherapeutics or antibiotics are used as a prophylactic, there is no danger in the prolonged retention of the packing Frequently it will almost fall out of the nose by its own weight.

Malignant tumors located in the sphenoethmoid region or the ethmoid sinuses or the posterior maxillary area may give rise to severe hemorrhage When bleeding cannot be controlled in such cases by the usual measures the external or internal carotid artery or the internal maxillary artery may have to be ligated. The external carotid artery supplies the lower portion of the nose while the internal carotid supplies the upper portion. The internal maxillary artery supplies the lower and posterior portions of the nasal cavity including the posterior portion of the maxillary sinus. Since the ethmoidal arteries are branches of the ophthalmic which springs from the internal carotid, this major vessel must be ligated for bleeding in the upper part of the nose Because of the complications which may follow tying of the internal carotid artery this procedure should not be done without careful deliberation.

Bleeding caused by ulceration from the lodgement of foreign bodies is easily controlled.

The technic of controlling nasal hemorrhage is important. Ordinarily a small piece of gauze or cotton placed firmly

mattress suture-dissection technic is continued until the last 6 or 12 mm (¼ or ½ inch) of lingual tonsil remains A controlled snare such as the Beck Schenk the loop of which can be pulled through gradually is used. Plenty of time is allowed for the removal of the final piece of tissue Following this, another mattress suture is placed through the tongue There is no postoperative bleeding if this technic is used Care must be exercised in the selection of the suturing needle The mattress sutures must not be placed too deeply to avoid later tissue necrosis and possible secondary bleeding

ALLISON J VOSSELER M D

6

Ligation of Carotid Arteries for Active Hemorrhage from Cancer of the Head and Neck

ONE of the emergency procedures in surgery is the control of hemorrhage produced by advanced malignant neoplasms. Eroding neoplasms of the head and neck may call for the ligation of the major arteries supplying these areas because of hemorrhage or the threat of hemorrhage The lack of ligation in acute hemorrhage or the delay of ligation in threatened hemorrhage may result in the loss of life In such instances it may be necessary to ligate the common carotid artery or the external carotid artery and sometimes only specific branches of the external carotid artery

The preservation of life by the timely ligation of the appropriate major artery may enable one to proceed with a radical curative operation at a later date If such a radical surgical procedure is untenable at least the threat of catastrophic hemorrhage with sudden death can be removed as one of the fears of the intelligent patient.

The common carotid artery may be ligated to control profuse hemorrhage from the deeper structures of the upper cervical regions, from ulcerating neoplasms of the throat, and to preclude rupture of an aneurysm. The external carotid artery or an appropriate branch may be ligated for acute hemorrhage, the threat of hemorrhage, or as a preparatory procedure in extensive operations on the jaw or upper neck, together with lesions of the pharyngeal wall Simultaneous ligation of the external carotid arteries will result in gangrene of the tip of the tongue the anterior portion of the floor of the mouth, the lower lip and a portion of the chin If the ligation of both external carotid arteries is to be considered, an interval of more than a week must separate each ligation. Ligation of the internal carotid artery is rarely called for in the surgical management of carcinoma of the head and neck.

Preoperative Considerations The surgeon who ligates the carotid arteries must bear in mind two things the carotid sinus syndrome, and hemiplegia, if the common carotid artery is to be ligated.

The carotid sinus has been proved to be a reflex-controlling mechanism of the endovascular blood pressure The dilated portion at the bifurcation of the common carotid artery is the site of origin of this reflex, through innervation

of the adventitia of the vessel Manipulation of the carotid sinus attendant upon ligation of either of the carotid arteries may produce a carotid sinus syndrome which results in episodes of unconsciousness and/or convulsions These attacks are the result of cerebral depression of the blood pressure If hemorrhage is present one has no course but to proceed in spite of the danger of this complication, and the prophylaxis mentioned below may not be em

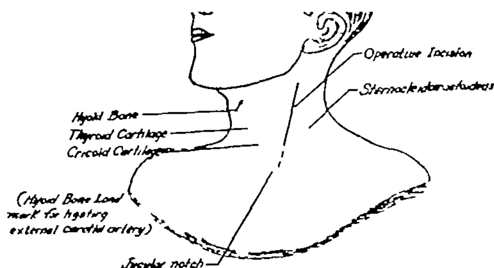


FIG. 1 Diagram illustrating operative approach to the carotid arteries. (Reproduced with permission from Ligation of Carotid Arteries For Advanced Malignant Neoplasms of the Head and Neck by Allison J Vosseler and Bernard J Ficarra. A M.A Archives of Surgery 58 35 [Jan.] 1949)

ployed. If hemorrhage threatens but is not present and there is some certainty of several days grace the common carotid artery on the affected side may be compressed daily gradually increasing up to a period of ten minutes If no undue symptoms occur one may proceed with the ligation of the common carotid artery If undue symptoms do present themselves, external carotid ligation is preferable Often, however the upper neck is so involved by neoplasm or radiation effect as to make the external carotid artery technically unavailable In these cases, one has no choice but to proceed with the common carotid artery ligation as follows When the common carotid artery is exposed a 0.5 per cent procaine hydrochloride solution should be injected into the region of the carotid bulb This solution is injected at the bifurcation of the carotid artery where the sensory receptive fibers originate Here the nerve leaves the sinus as the intercarotid nerve (nerve of de Castro) to join the glossopharyngeal nerve Through this pathway the afferent impulses pass between the carotid sinus and the medullary center The procaine hydrochloride blocks this reflex and thereby prevents the syndrome After common carotid ligation or the rare internal carotid artery ligation a too frequent sequela is hemiplegia. In our experience this has occurred as late as ten days postligation One may expect to decrease the incidence of hemiplegia by the postoperative use of heparin and dicumarol [2]

Operative Approach to the Ca

rotid Artery The surgical approach to the carotid arteries is by means of an incision along the anterior margin of the sternocleidomastoid muscle The center of the 8 cm (3½ inches) incision is at the level of the cricoid cartilage Retraction of the sternocleidomastoid muscle posteriorly brings into view the omohyoid muscle inferiorly This muscle may be divided if necessary The descending hypoglossal nerve is retracted laterally For more adequate exposure the thyroid gland may be drawn medially if necessary This enables the common carotid artery to be more easily identified Silk ligatures may then be placed about the artery from the neighboring internal jugular vein and vagus nerve

The same approach is employed for the external carotid artery The site of selection for ligating this vessel is between the superior thyroid and the lingual artery The landmark in choosing the site of ligation of the external carotid artery is at the level of the greater horn of the hyoid bone In ligating the external carotid artery the superior laryngeal nerve must be avoided. This structure lies behind the artery

The cervical portion of the internal carotid artery is identified through the same exposure as that used for the external carotid artery In our experience we have ligated the internal carotid artery once This was done after ligation of the common carotid artery when it was found that the temporal pulse persisted. Subsequently ligation of the internal carotid artery at the same operation then caused the temporal pulse to disappear Late contralateral hemiplegia ensued. In the cases presented, the arteries were ligated with black silk The ligations of these vessels are done gradually in order to avoid sudden fall in cerebral circulation This method of gradual occlusion of the vessel is also prophylaxis against the stimulation of the carotid sinus By this means of occlusion the silk ligature is drawn upward and the artery pushed downward with a clamp The method enables release of the artery in the event that unusual symptoms referable to the carotid sinus develop (Fig. 2) A sudden

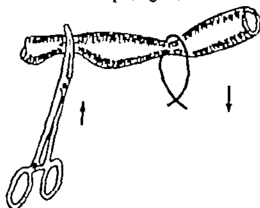


FIG. 2. Method of gradual arterial compression by pulling upward on the ligature and pressing downward with a clamp (This illustration is taken from Ligation of Carotid Arteries For Advanced Malignant Neoplasms of the Head and Neck by Allison J Vosseler and Bernard J Ficarra. A.M.A Archives of Surgery 58 35 [Jan.] 1949 Reprinted with the permission of the A.M.A.)

rise in the pulse rate may occur at the time of ligating the common carotid artery and is a warning against sudden ligation The rise in pulse rate would be the result of the lowered intracarotid bulb pressure In those individuals with a sensitive carotid sinus reflex, manipulation of the carotid artery or its major branches produces a fall in pulse rate and the blood pressure This may be dangerous to the patient. By injecting the carotid bulb area with procaine the reflex may be abolished. The surgeon may then proceed to ligate the artery without fear of further alterations in the pulse rate

Our data in ligating the carotid arteries for the advanced malignant growths of the head and neck are based on twenty-seven cases In this series the youngest patient was thirty three years of age and the oldest seventy-seven Twenty-four patients were men and three were women All of them had advanced neoplasms The majority were not satisfactory operative risks

One patient with carcinoma of the tonsil died of an exsanguinating hemorrhage the night before she was scheduled for carotid ligation The life of one patient with carcinoma of the cheek and upper neck was saved by quick action of the resident surgeon who ligated the external carotid artery in the dressing room.

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ARNOLD S JACKSON M D

7

The Treatment of the Immediate Complications of Thyroidectomy

THE prevention of complications, both immediate and remote following thyroidectomy is a subject of extreme importance to those interested in surgery of the thyroid gland. The statistical studies of operative records reveal the number of patients who were successfully operated on, but tell nothing of the patients whose lives perhaps hung in the balance for hours or days. An error in judgment at the operating table may be responsible for the development of complications that alter the entire future of the patient's life although no mortality occurs

In perhaps no field of surgery are complications more prone to develop than following operations on the thyroid. This is so true that there are few surgeons who have not experienced most of the unfortunate sequelae at some time during their careers

Complications following thyroidectomy may be divided into three classes, immediate delayed, and remote In this discussion only the immediate complications are to be considered They may be listed as follows

1 Injury of the recurrent laryngeal nerve.

2 Hemorrhage

3 Injury or collapse of the trachea.

4 Air embolism

5 Acute hyperthyroidism

6 Anesthesia complications

7 Injury of the parathyroid glands

8 Cardiac failure

1 Injury of the Recurrent Laryngeal Nerve· *This may be a most serious and even fatal complication* It is the most serious and one of the most frequent sequelae

Prevention is the most important factor Two methods have been described for avoiding injury of these vital structures

(a) Since 1925 I have successfully employed the following technic without serious consequence Hemostats are placed on the important veins on the lateral walls of the goiter after the method of Halstead at least one-half inch removed from the vicinity of the nerve The gland is then hollowed out by an intracapsular dissection in the same manner that an egg is hollowed out of its shell A small amount of wedge-shaped tissue is preserved at the base of the dissection and special care is taken of both lower poles Any remaining small cysts or adenomas can be easily removed by the electrosurgical loop Any unsecured vessels are then ligated or coagulated within the capsule

the lateral veins are ligated. No attempt is made to isolate and ligate the inferior thyroid artery as is done for the superior thyroid artery except in the case of total lobectomy for malignancy. The capsule is then resutured. By using this method, the danger of injury of the recurrent laryngeal nerve is almost nil.

(b) The method popularized by the Lahey group is based on an entirely different concept, and, in their experience and that of many others using it, it is safe and satisfactory. In this method the recurrent laryngeal nerves are located at the start of the operation and are sufficiently exposed to determine their course. The inferior thyroid arteries are usually ligated after the nerves are located.

Prevention, then, is the most important factor concerning this complication. If unfortunately one nerve is injured, it may be recognized in some instances at once by stridor or voice change and it may be possible to remove a responsible ligature or suture. Such is not often the case. The injury may not be ascertained until the damage is irreparable.

If both nerves are injured during thyroidectomy, severe dyspnea and aphonia may occur particularly if the abductors are involved, and immediate tracheotomy is required. However, these conditions may develop gradually over a period of days or even weeks, only then necessitating tracheotomy.

If only one recurrent laryngeal nerve is injured, the other will then usually overcompensate. In time the voice and breathing may become much improved. The degree of recovery depends somewhat upon the severity of the injury. In some instances where recovery is rapid only secondary involvement, such as edema or scar tissue, may be responsible.

If both nerves are paralyzed, the patient must be subjected to the King operation or one of the other procedures devised to overcome this complication. In many instances these operations have resulted in a restoration, partial or nearly complete, of the normal voice and breathing; but the operation itself is a major procedure recommended only for those who have made a special study of its hazards and technic.

2. Hemorrhage. This is a rare complication of the experienced thyroid surgeon but may prove a serious and even fatal sequela of the inexperienced operator. Its most frequent cause is from tearing the lateral or median vein. In elderly persons these vessels are extremely friable and may easily be torn by blunt finger-dissection of the capsule or when elevating the goiter from its bed or while stripping the capsule. Usually it is desirable to locate the vein or veins before making much upward traction on the goiter and then carefully divide and ligate. If the vessel is inadvertently torn and retracts toward the mediastinum, as in the case of an intrathoracic goiter, great care must be exercised not to injure the recurrent laryngeal nerve while controlling the bleeding. A pack may temporarily suffice to check the bleeding but seldom is permanently effective.

The superior and inferior thyroid vessels are not often the cause of serious bleeding. The superior is more easy of access and may usually be doubly clamped and sutured with ease, providing the upward dissection of the skin flap and exposure of the upper pole is sufficient.

Hemorrhage within the capsule may be annoying but should not be serious providing the field has been kept clear

of hemostats as the operation proceeds Dr Charles Mayo used to say at this point in a thyroidectomy "An old fox always cleans up his steps as he goes" Whether or not that is literally true I do not know but it was one of the best pieces of advice ever given me Another method of checking this bleeding is that of simply elevating the remaining gland tissue by the left index finger making pressure on the trachea and thus tem porarily checking the bleeding and per mitting the vessel then to bleed a little and be detected and clamped

In many instances bleeding within the capsule may be easily controlled by re suturing the lateral and median walls of the resected tissue using care of course, not to suture too deeply and thus pick up the nerve If the bleeding vessel is deeply located it may be desirable to pack in one or two pieces of gelfoam and then suture Besides pressure the use of hot gauze sponges may be of aid in temporarily arresting bleeding In operating I coagulate most of the small vessels within the capsule by the elec trosurgical knife The vessels on the outer walls are sutured.

Finally slight, persistent, annoying bleeding may occur on the outer surface of the capsule and may prove difficult to stop Here again, gelfoam may be employed to advantage, or a section of muscle tissue may be partially excised and sutured over the oozing surface as a flap

Bleeding during the course of thy roidectomy today is not the problem it presented prior to the use of Lugol's solution in 1922 Without preoperative preparation with iodine, resection of a diffuse hyperplastic gland may prove to be an extremely bloody operation While that complication is no longer en- countered, the use of the antithyroid drugs proved an annoying problem from a bleeding standpoint until we learned that by stopping these drugs ten days prior to thyroidectomy and substituting iodine the tendency to bleed was well controlled.

One of the great advantages of super ficial nerve block anesthesia which I have employed since 1928 is that it per mits the patient to cough at the com pletion of the resection and before the incision is closed thus causing any un- detected vessel to bleed This step alone has saved me from many cases of post operative hemorrhage, because, fre quently small veins or even arteries are so collapsed that they will not bleed while the patient is absolutely quiet.

One of the most dramatic and serious complications of thyroidectomy is a postoperative hemorrhage developing a few hours after operation All nurses and house doctors should be trained to be on guard for this emergency and ad- vised what to do The usual signs and symptoms follow The patient may be restless there is gradually increasing dyspnea accompanied by cyanosis and fullness of the neck as pressure on the trachea accumulates from the bleeding In some instances dyspnea increases so quickly that the patient rapidly goes from a state of severe anoxemia to un consciousness All medical personnel should be directed to turn their atten- tion to this patient at once If time per mits, he should at once be brought to the operating room and oxygen given immediately For fifteen years I have had an oxygen tank available on the dressing cart for this purpose Fortu- nately it has not been needed, but there were times in the past when delay in securing it could have proved fatal.

A hasty preparation of the operative field and removal of the skin clips or

silk sutures and of the underlying sutures will then permit the blood clots to gush out or be removed gently and the source of the bleeding be detected This is not always an easy matter and may prove more difficult than the thyroidectomy Usually however with good light, good exposure and good assistance it can readily be found and secured

This emergency may not occur until the middle of the night, and the house staff should be advised that, if necessary the incision should be opened in bed or on the elevator if the occasion should demand and that for the moment sterile conditions may have to be overlooked. It is better to have a live patient with an unsterile wound than a dead patient with a sterile wound The bleeding itself is seldom serious and may for the time being be controlled by packing.

Attention to these important details has in years past saved the lives of several patients and no thyroid surgeon can afford to relax his vigilance in this regard

3 Injury or Collapse of the Trachea Injury to or cutting the trachea is about the only complication I have not encountered in thirty years of operating on thousands of patients with goiter It is perhaps the least serious of the immediate complications and requires no special mention since the condition can be taken care of easily

Collapse of the trachea is a much more serious problem. A leading thyroid surgeon once told me he had never encountered this condition, yet it was not an infrequent experience for Kocher I have seen three instances in which it occurred prior to operation with fatal results in all. Twice it occurred on the operating table and once it followed operation the patient was saved in these three cases

In the cases occurring prior to operation the patients were told of the possibility in two instances and were advised to have immediate surgery Both were elderly patients and both delayed too long, one dying a few minutes after admission and before tracheotomy could be performed.

The third case was that of a young, husky farmer twenty-nine years of age The possibility was not suspected, although it was known that he had an intrathoracic goiter While being brought to the operating room he complained of dyspnea, but it was not until he was placed on the operating table that sudden and severe dyspnea developed Tracheotomy was performed in a matter of minutes but, although normal heart beat was restored the patient died the next day from cerebral damage without ever regaining consciousness

During the course of thyroidectomy a woman of sixty five years with a left intrathoracic goiter suddenly became dyspneic following resection of the swollen right lobe The pressure exerted by the large left lobe once the right lobe was removed evidently was too much and the trachea collapsed A desperate condition called for a desperate remedy so the large left lobe was at once forceably elevated, and as a consequence the median vein was torn Fortunately the vessel was easily secured, and the dyspnea subsided as the trachea was released from the excessive pressure and straightened After sixteen years this patient is still alive

In another case the trachea collapsed a few minutes after the patient returned to her room Again it was a large retrotracheal intrathoracic goiter With

the patient in bed a tracheotomy was performed by an alert associate but it took several weeks before the greatly weakened trachea recovered sufficiently to permit the tube to be removed

While this complication is unusual, it is one that may happen at any time and, as cited, under many different circumstances The alert thyroid surgeon will not be caught asleep when it does occur

4 Air Embolism Again, this is a complication seldom encountered and less often written about Yet one excellent surgeon, Dr Donald Guthrie, reported eighteen cases of which he had knowledge This unfortunate accident happened to me in 1924 after I had just completed my first series of 300 thyroidectomies without a mortality and, as is the experience of most young surgeons I was beginning to consider my record as rather unique Just after thyroidectomy was completed and the dressing applied the patient who was sitting upright on the table suddenly became nervous and started to cough violently Instantly there was a noise as of air escaping from a bicycle tire, and the patient turned cyanotic and was dead in a few seconds It was our impression after opening the wound that either a small vessel in the sternothyroid muscle had not been securely ligated or the violent cough had loosened the ligature and that air had been aspirated. Since then I have always seen to it that either my assistants or myself carefully ligated these vessels

In another instance, during the course of an extremely difficult operation to determine the cause of bleeding in a case of an infected postoperative thyroidectomy wound, an air embolism occurred, but the patient recovered. In this case the patient's head was immediately lowered to the floor, and although she was unconscious for seven hours and sustained a slight hemiplegia recovery was eventually complete I have seen this complication occur twice to other surgeons performing thyroidectomies

5 Acute Hyperthyroidism Prior to the use of Lugol's solution this complication was of common occurrence in operating for exophthalmic goiter For that reason injection of a small amount of hot water into the thyroid gland was devised not so much in the hope of destroying some of the gland (phenol was even injected for this purpose) but to ascertain what reaction the patient would have Only a few years ago Dr George W Crile Sr., renowned thyroid surgeon, was performing thyroidectomies in the patient's bed after several days trial operations so that the gland could eventually be stolen without alarming the patient and thereby reducing the reaction. Until the advent of the antithyroid drugs many surgeons including Dr Frank Lahey advocated ligation operations to render less severe the hyperthyroid reaction from thyroidectomy

Plummer made his great discovery of the efficacy of iodine in 1922 and in the following year I reported in *The American Journal of Surgery* a study of its use in the surgical treatment of exophthalmic goiter By 1924 the ligation operation was abandoned in favor of a primary thyroidectomy and in March, 1927 a report of 120 cases so treated was published in *Surgery Gynecology and Obstetrics* During the period between 1922 and 1924 it had been proved that the hyperthyroidism of exophthalmic goiter occurring during or

immediately following thyroidectomy could be controlled by iodine

Iodine, however does not have the same effect in toxic nodular (adenomatous) goiter as was shown by a study of 279 cases reported in *The Journal of the American Medical Association* in April, 1936 by Freeman and me. This study showed that sixty two per cent were benefited slightly or not affected, while thirty-eight per cent were made worse Hyperthyroidism continued to be an important factor in the surgical treatment of this condition often necessitating a two-stage thyroidectomy since ligation had never proved of value. Finally when Astwood and others brought forth the use of the thiouracil drugs in 1943 it was possible to abandon the two-stage thyroidectomy in favor of a primary thyroidectomy in toxic adenomatous goiter It was thought by some that the drug would even eliminate the necessity for surgery in the treatment of hyperthyroidism However after two years clinical experience with thiouracil, I stated in *Surgery Gynecology and Obstetrics* in 1946 that in my opinion "Thiouracil Will Not Replace Thyroidectomy " That conclusion is now generally assumed to be correct, although I have reported cases of exophthalmic goiter in children cured with propylthiouracil. A study of over 500 cases in adults showed that thyroidectomy is still the method of choice but that these antithyroid drugs are of distinct value in the preoperative preparation of patients with advanced cases of toxic adenomatous goiter and that they have definitely eliminated the factor of hyperthyroidism if used properly and in adequate amounts over a sufficiently long period of time

Since 1949 I have not used the antithyroid drugs in the preoperative preparation of exophthalmic goiter but I returned to the use of iodine enti If the latter is used in doses of drops three times a day for ten to f teen days and is used postoperati in amounts of five times as great, degree of hyperthyroidism can controlled

I rarely use sedatives postoperati to control nervousness but there is objection to small amounts of ph barbital nembutal, or pantopon. C gen intravenous fluids, and transfus are almost never used In fact, if surgeon has the required skill if he the patient s confidence and if the tient has received adequate preparat iodine will control the hyperthyroic of exophthalmic goiter and pati with toxic nodular goiter will react differently than those with nont goiters, if they have been properly pared with antithyroid drugs.

6 **Anesthesia Complications** writer has had occasion to resort to eral anesthesia on only three occas during the past thirty years Once to grant the request of a doctor other was for a terrified non Eng speaking patient, and the third was please an associate in an operation formed for a large intrathoracic go As a consequence, I have had no exp ence with anesthesia complications, cause with the use of the superfi nerve block anesthesia they just do occur

Pneumonia likewise rarely occ with nerve block anesthesia My perience is limited to one case occurri on the eighth postoperative day in severe diabetic a fatality resulted cause antibiotics had not yet b discovered

It is important to see that every tient leaves the operating room in g

condition Too often the surgeon leaves this important step to others I have always seen to it that the patient had a dry gown and if tracheitis was anticipated steam inhalations were ordered If the patient were elderly and feeble he was placed in a steam tent.

7 Tetany The time to prevent this complication is at the operating table By using the technic described above no cases of tetany have occurred since a report of three cases I made in 1925 in the *Annals of Surgery* This condition can and should be prevented Its treatment is not a part of this chapter

8. Cardiac Failure This complication has never occurred in my experience while performing thyroidectomy This I believe is due to the use of nerve block rather than general anesthesia, since the patient is at all times under the surgeon s control

HANS VON LEDEN, M.D

8

Tracheotomy

TRACHEOTOMY may be defined as the surgical creation of a window in the trachea Since such an operation is performed only for the relief of serious respiratory embarrassment, a tracheotomy is usually an emergency procedure. Its success has been attested by countless surgeons over the past two thousand years Asclepiades of Prusa in Bythinia is credited with the performance of the first life-saving tracheotomies in the first century B C and the basic fundamentals of the surgical technic have remained unchanged since the sixteenth century when Fabricius of Aquapendente described the use of a silver cannula to maintain the tracheal opening. Recent advances in medicine however increase the importance of tracheotomy by the addition of a new series of indications and promote the safety of the procedure by valuable refinements in the technic

Indications Any *obstruction of the upper respiratory tract* resulting in respiratory embarrassment is a clear cut indication for tracheotomy (Table 1) The basic pathology in all these cases consists of a gradual narrowing of the airway tracheotomy was designed to bypass this obstruction and thus restore an adequate air exchange

TABLE 1
INDICATIONS FOR TRACHEOTOMY

Upper Respiratory Obstruction

(1) Supraglottic obstruction
- Acute epiglottitis
- Retropharyngeal abscess
- Ludwig's angina
- Injuries of oral cavity or pharynx
- Jaw fractures

(2) Temporary obstruction of glottis
- Inflammation
  - Severe laryngitis
  - Diphtheria
  - Scarlet fever
- Allergic edema
- Foreign bodies
- Spasm (laryngismus stridulus)

(3) Prolonged obstruction of glottis or upper trachea
- External compression
  - Tumors of upper esophagus or thyroid
  - Postoperative hemorrhage
- Internal constriction
  - Tumors
  - Tuberculosis
  - Syphilis
  - Congenital webs
  - Fractures of laryngeal cartilages
  - Stenosis following
    - Perichondritis
    - Surgery
  - Bilateral abductor paralysis

Clinical indications for the performance of a tracheotomy in obstructing lesions of the upper respiratory tract are manifested by Laryngeal stridor Restlessness Retractions Cyanosis

In recent years tracheotomy has also been used successfully in the treatment of an increasing number of entirely different conditions which are characterized by an obstruction of the lower respiratory passages or *secretory obstruction* (Table 2) The purpose of tracheotomy in this group of cases lies in the removal of obstructing secretions from the tracheobronchial tree and in the prevention of pulmonary complications and asphyxia.

The basic pathologic physiology in all cases of secretory obstruction consists in failure of the cough mechanism, which normally clears the respiratory passages of accumulated secretions Any interruption of this cough reflex by coma or severe general debility by depression or destruction of the respiratory center in the medulla, by anesthesia of the larynx by paralysis of the diaphragm or intercostal muscles by fractures of the ribs or cervical spine or by any other cause, results in the accumulation of secretions in the lower respiratory passages Locally this collection of retained and aspirated material causes obstruction edema, spasm of the bronchioles, and scattered areas of atelactasis or pneumonia Systemically the secretory obstruction produces a triad of progressive chemical changes in the blood, anoxemia, hypercapnia, and acidemia culminating in death by asphyxia.

TABLE 2

INDICATIONS FOR TRACHEOTOMY

Lower Respiratory or Secretory Obstruction

(1) Medical disorders
- Infectious diseases
  - Bulbar poliomyelitis
  - Spinal poliomyelitis
  - Tetanus
  - Epidemic encephalitis
- Neurologic conditions
  - Disseminated encephalomyelitis
  - Cerebrovascular accidents
- Muscular weakness
  - Myasthenia gravis
  - Convalescent poliomyelitis
- Poisonings
  - Botulism
  - Drug poisonings (barbiturates, etc.)
- Coma or severe debility
  - Uremia, etc.

(2) Surgical disorders
- Postoperative complications
- Postanesthetic complications

(3) Obstetric disorders
- Eclampsia

(4) Injuries
- Cranial injuries
  - Injuries of cervical spine
- Chest injuries
- Thermal injuries
  - Blast burns
  - Refrigeration

In all serious cases of secretory obstruction tracheotomy is the treatment of choice because it bypasses any incidental upper respiratory obstruction, such as a pharyngeal pool of mucus, permits easy and continued aspirations of the lower respiratory passages, facilitates the removal of crusts and secretions by irrigation, eliminates the necessity of repeated bronchoscopic aspirations, forestalls impending exhaustion of a patient by reducing the respiratory effort, decreases the dead space of respired air and permits bedside care by personnel without special training

Clinical indications for a tracheotomy in secretory obstruction include

- Respiratory distress
  - Cyanosis
  - Moist rales
  - Grunting respirations
  - Laryngeal stridor
- Ineffective cough
- Pharyngeal pooling of mucus
- Stupor or coma with aspiration of pharyngeal secretions or vomitus.

Indications for tracheotomy in *acute laryngotracheobronchitis* are discussed separately because this entity combines

an acute upper respiratory obstruction of the larynx with a gradual accumulation of secretions in the lower respiratory passages It deserves special consideration because it is the leading cause of respiratory difficulties in infants and small children The pathologic picture is that of a descending inflammation of the mucous membranes lining the respiratory tract, followed by congestion edema, and exudation of a thick tenacious secretion. Secondary vascular changes take place as a result of increased negative intrathoracic pressure, with severe pulmonary and cardiac embarrassment. The main objectives of a tracheotomy in acute laryngotracheobronchitis consist of an immediate restoration of the airway and of normal intrathoracic pressure and the prevention of sudden asphyxia or gradual exhaustion.

Clinical indications for tracheotomy in acute laryngotracheobronchitis may be classified under three separate headings

(1) Severe obstruction
    Change in stridor
    Restlessness
    Deep retractions
    Circumoral pallor—cyanosis
    Anxiety

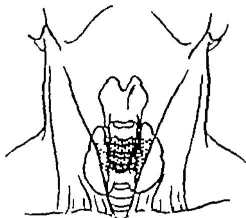
(2) Exhaustion
    Listlessness
    High fever
    Rapid, shallow breathing
    Weak, fast pulse.

(3) Prolonged obstruction with no improvement on medical management.

Contraindications If a tracheotomy is indicated *no* contraindications exist. A correctly performed tracheotomy is a harmless procedure while undue deliberation or unnecessary delay are likely to cost the life of a patient

Surgical Anatomy The cervical trachea of an adult is about 6.25 cm (2½ inches) in length, and consists of the upper eight or nine tracheal rings. It is more superficial in its upper portion where it is separated from the skin only by the ribbon muscles (sternohyoid and sternothyroid) and by the cervical fascia. The superficial layers of cervical fascia envelop the ribbon muscles and meet in the midline to form the linea alba The deep or pretracheal layer of fascia covers the trachea It also forms the suspensory ligament of the thyroid isthmus which usually crosses the trachea between the third and fifth tracheal rings. The lower part of the cervical trachea is surgically less accessible it is located more deeply in the neck, behind a thick layer of connective tissue and numerous blood vessels

The important surgical landmarks for the performance of a tracheotomy in an adult may be outlined by an irregular quadrangle (Fig 1) The bases of this tracheotomic quadrangle are formed by the cricoid cartilage above and the thyroid isthmus below while the sides conform to the inner margins of the two



Tracheotomic quadrangle

Fig 1 Tracheotomic quadrangle Bases are formed by cricoid cartilage above and thyroid isthmus below sides by sternomastoid muscles. Contents include upper two or three tracheal rings, the ideal location for tracheotomy

sternocleidomastoid muscles Within the confines of this quadrangle one encounters no important blood vessels or other structures

Preoperative Medication No preoperative medication is warranted in preparation for an emergency tracheotomy Sedatives have a depressing effect on the respiratory center and must *never* be used in patients with respiratory distress Symptoms of restlessness and anxiety so frequently observed in cases of respiratory embarrassment are the direct result of oxygen want they promptly subside after the restoration of an adequate airway *i.e* after a tracheotomy

Anesthesia Local anesthesia is the method of choice for an orderly tracheotomy It should be supplemented by verbal reassurances throughout the operation to allay the fearful apprehension of a patient who is fighting for air Oxygen should be administered by the intranasal route until satisfactory breathing has been restored. No anesthesia whatever is necessary in cases of impending asphyxia and general anesthesia is always contraindicated in patients with respiratory difficulties

Instruments In each hospital it is advisable to have two sets of tracheotomy instruments in readiness one for adults and one for children Each set should contain the complete assortment (Table 3) but the instruments in the children's set should be correspondingly smaller in size

Table 3

INSTRUMENTS FOR ORDERLY TRACHEOTOMY

(1) Luer-Lok control syringe for local anesthesia.
Assorted needles
Medicine glass for 30 cc. of 1% procaine solution (with 5 drops of 1 10,000 adrenalin)
(2) Scalpels
(3) Blunt end bistoury
(4) Scissors (dissecting and suture)
(5) 6 hemostats
(6) 3 retractors
(7) Tracheal tenaculum
(8) 1 cc. syringe with 22 gauge needle for topical anesthesia of trachea
Medicine glass for 2 cc. of 5% cocaine solution
(9) Tracheal cannulae (size 6 to 8 for adults, 4 to 5 for adolescents, 2 to 3 for children, 1 for infants)
Linen tape
(10) Needle holder
(11) Full curved needles, small
(12) Catgut ligatures
(13) Suture material
(14) Gauze sponges
(15) Aspirator with soft rubber catheter (size 10 F) for tracheal aspiration

Surgical Technic: While an orderly tracheotomy in an adult is not a difficult surgical procedure, desperate emergencies or operations on infants and small children may tax the ingenuity of even the most experienced operator Careful adherence to a good surgical technic minimizes the discomfort of the patient during and after the operation, and prevents undesirable complications For clarity the surgical technic of an *orderly tracheotomy* is described in a series of stages

POSITION A sandbag is placed under the shoulders of the patient to permit full extension of the head thus placing the trachea into the most accessible position (Fig. 2a)

LOCAL PREPARATION The operative area is shaved, cleansed with soap and water and prepared with an antiseptic tincture

LOCAL ANESTHESIA The anesthetic agent (1% Procaine with adrenalin) is injected subcutaneously over the cervical trachea (Fig 2b) The injection is confined to the midline because

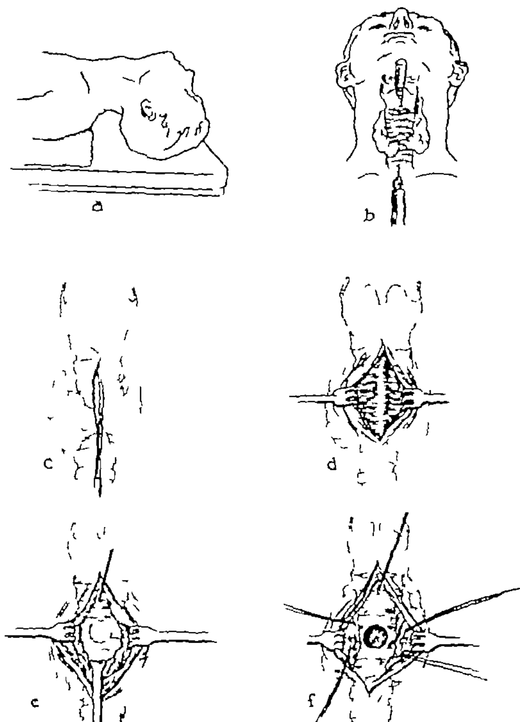


FIG. 2. Orderly tracheotomy (a) Shoulders are elevated by sandbags to attain complete extension of head (b) Injection of local anesthetic is confined to surgical area in midline of neck (c) Incision passes through skin and subcutaneous tissues. (d) Lateral retraction exposes linea alba between ribbon muscles. (e) Thyroid isthmus retracted caudad, exposing third and fourth tracheal rings. Tracheal tenaculum under first tracheal ring fixes trachea for incision. (f) High thyroid isthmus has been divided sutured, and retracted laterally for exposure Round segment removed from anterior tracheal wall for introduction of tracheal cannula.

there is no necessity for lateral dissection or anesthesia

INCISION The original incision extending straight from the thyroid cartilage to a point below the thyroid isthmus is carried down to the cervical fascia (Fig 2c) Skin vessels are clamped.

DISSECTION The skin edges are separated, and the linea alba is exposed between the ribbon muscles (Fig 2d) The dissection is deepened in the mid line to expose the cricoid, trachea, and thyroid isthmus All bleeders are clamped Caution should be observed during this stage of the operation not to dissect lateral flaps or to denude the trachea of its fascial investment such false moves provide access to the fascial planes of the neck, and invite complications

THYROID ISTHMUS If the thyroid isthmus extends above the fourth tracheal cartilage an attempt is made to retract it caudad to permit adequate exposure of the second and third tracheal rings (Fig. 2e) If this maneuver is not successful, the isthmus is divided in the midline between two hemostats The stumps are then ligated with strong sutures and retracted laterally (Fig. 2f)

TRACHEAL ANESTHESIA A few drops of 5 per cent cocaine solution are instilled into the trachea by means of a syringe and needle through one of the interannular membranes

HEMOSTASIS All clamped or bleeding vessels are now ligated, and complete hemostasis is assured.

TRACHEAL FIXATION The trachea is fixed and elevated by a tracheal tenaculum which is passed under the cricoid cartilage or the first tracheal ring (Fig. 2e)

TRACHEAL INCISION The ideal site for the tracheal incision are the second and third tracheal rings (Fig 2e) this location effectively prevents injury to the cricoid cartilage or larynx. By sharp dissection a round segment is excised from the anterior tracheal wall, closely approximating the diameter of the indicated tracheal cannula (Fig. 2f) It is advisable to use a blunt end bistoury for this excision or to guard the blade of the scalpel with a guiding finger in order to protect the soft posterior tracheal wall and adjoining esophagus from injuries This technic of removing a segment from the anterior tracheal wall is designed to eliminate complications (see below) and to facilitate the postoperative exchange of cannulae

INSERTION OF CANNULA The tracheal cannula is readily introduced through the window into the trachea, and the obturator is immediately withdrawn. The size of the individual cannula should be proportionate to the tracheal lumen size 1 for infants sizes 2 and 3 for children sizes 4 and 5 for adolescents, sizes 5 and 6 for women, and sizes 6 and 7 for men The selection of a relatively large cannula is desirable but pressure on the tracheal mucosa must be avoided.

CLOSURE A tracheotomy wound should not be closed tightly While the upper and lower ends of the original incision may be approximated by sutures the area around the tracheal cannula should remain open to permit adequate drainage In the presence of an infection, or in small children, it is often advantageous to keep the wound open by surrounding the proximal end of the cannula with vaseline gauze

DRESSINGS Standard size gauze pads are split halfway down the center and slipped under the shield of the cannula as a dressing The head should be returned to the normal position before the

plications and must not be performed indiscriminately It is far safer and easier to introduce a bronchoscope or a Lifesaver and then proceed with an orderly tracheotomy

Mosher Lifesaver The Mosher Lifesaver (Fig 6) is a curved hollow metal tube with a long shaft. It is available in three sizes and should have a place in each physician s bag.

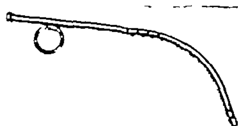


Fig 6 Mosher Lifesaver

Method of Introduction The left index finger is passed into the patient s throat, and the epiglottis is identified and pulled forward With the finger as a guide the Lifesaver is introduced in the midline and the tip of the instrument is advanced through the laryngeal slit into the trachea In a child, in whom the laryngeal opening may be very small, this maneuver is accomplished by retracting the epiglottis and palpating the arytenoids which arise as small projections on each side of the midline

Tracheotomy in Children As mentioned previously a tracheotomy in an infant or small child is not an easy procedure and may tax the skill and ingenuity of even the most experienced surgeon The trachea of a small child is located deep in the neck It is no larger in diameter than a drinking straw rubbery in consistency and may well be confused with the common carotid artery but a short distance away When exposed, the infantile trachea is found slippery and elusive while its structural components are soft and tear readily The thyroid isthmus of a child is broader and extends higher than that of an adult, covering the upper three or four tracheal rings Laterally the cervical pleurae describe an excursion into the neck during extension of the head Finally the youngster is usually frantic with fear and tosses about violently unless well restrained. To perform even an orderly tracheotomy under these circumstances is no mean feat and a rush tracheotomy on a struggling infant is well nigh impossible

Helpful Hints (1) In cases of impending asphyxia, rush tracheotomies should be converted into orderly tracheotomies by the insertion of a bronchoscope endotracheal tube or Mosher Lifesaver (2) Strict adherence to the midline and to the central portion of the neck during the original incision prevents accidental injury of the pleurae or involvement of the mediastinum (3) A complete set of small instruments facilitates the dissection and the tracheal incision (4) The preoperative introduction of a bronchoscope also aids the dissection because the presence of a firm shaft in the trachea steadies the latter during the operation and provides a firm and illuminated landmark (5) Cephalad retraction of the thyroid isthmus is often expedient during the tracheal incision (Fig 7) This maneuver permits the isthmus to act as a soft cushion for the delicate cricoid cartilage after the tracheal cannula has been placed in position. (6) Finally it is helpful to station an assistant or an anesthetist at the head of the table with instructions to watch the general condition of the patient, steady the head of the child in the midline and supervise the administration of oxygen during the operation.

POSTOPERATIVE CARE The responsibility of the surgeon does not end with the restoration of the airway by the introduction of a tracheal cannula Tracheotomized patients require expert and continuous supervision to maintain their airway This postoperative care is so important that it should never be relegated to another physician or to an inexperienced member of the house staff

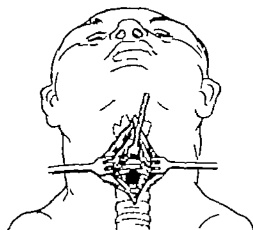


FIG. 7 Tracheotomy in children.—Cephalad retraction of thyroid isthmus to expose second and third tracheal rings.

SPECIAL CARE The specific care of a tracheotomized patient can be summed up under the heading of airway maintenance Such patients demand *constant surveillance* until they are able to minister to their own needs. Tracheotomized children and invalids in particular must never be left alone for a moment, since they are unable to attract attention should they need immediate assistance Relatives and even nurses should be impressed with this necessity for constant vigilance and should be acquainted with the danger signals of impending obstruction. The *inner cannula* of the tracheotomy set should be removed and cleaned at frequent intervals Again it is not sufficient to leave the details of this procedure to the caprice of the individual attendant Adequate *humidification* is of great value since it restores the necessary degree of moisture in the trachea and bronchi and prevents the formation of dry crusts For this purpose a heatless humidity unit is superior to the old fashioned croup kettles which heat the surrounding air and thereby often decrease the relative humidity of the room Secretory obstruction calls for frequent *aspirations* of the lower air passages by means of a soft rubber catheter The administration of the proteolytic enzyme *trypsin* by aerosol technic, loosens the secretions and facilitates their effective removal. Occasionally it may be necessary to *irrigate* the lower air passages with a few drops of normal saline but this measure can usually be avoided by adequate humidification and trypsin therapy *Dressings* should be changed frequently whenever they are soiled, for cleanliness of the wound promotes rapid healing

GENERAL CARE The general care of a tracheotomized patient is designed to support the specific measures outlined above A *diet* of soft foods is usually well tolerated In the presence of dysphagia Levine tube feedings may be necessary while patients with pharyngeal paralysis and vomiting *require* parenteral fluids to maintain an adequate fluid balance Tracheotomized patients with secretory obstruction should be placed in a *position* of dependent drainage This posture encourages spontaneous drainage of the obstructing secretions from the lower air passages, and permits the aspiration of nasal and salivary secretions from the nasopharynx by constant water suction *Oxygen* should be humidified by passage through a water container be

fore it is piped into the tracheal cannula *Antibiotics* or chemotherapy should be prescribed as indicated. *Pencil and paper* should be provided for purposes of communication since the tracheal cannula interferes with normal voice production Last but not least, there should be an explicit order on the record of each tracheotomized patient *forbidding* the administration of opiates or atropine Opiates lower the struggle for air and prevent expectoration of the accumulated secretions by inhibiting the cough reflex while atropine increases the stickiness of the exudate and promotes *crusting*

ACCESSORIES The following accessories should be ready for immediate use (1) A duplicate tracheal cannula of the same size and shape (2) a mechanical aspirator and (3) an oxygen tank. A bronchoscopic set should also be available if needed.

DECANNULATION The date of decannulation depends on the resolution of the obstructive process Removal of the tracheal cannula should not be attempted until patency of the normal air way has been assured In adults with an upper respiratory obstruction an indirect laryngoscopic examination affords this information, while in secretory obstruction the return of the cough reflex and the gradual cessation of secretion indicates the stage of recovery In infants and children however it is always wise to test the normal route before the cannula is removed If the cannula is small enough to permit the bypassage of air in the trachea it is gradually occluded by a series of cork or rubber stoppers. Decannulation should be deferred until the child is able to breathe and sleep comfortably with a fully occluded cannula. In an infant it may be necessary to substitute a smaller cannula before decannulation is deemed safe

After the tracheal cannula has been removed the wound edges are approximated with an adhesive tape bridge the latter is changed daily until the wound has healed Excision of the fistula is not necessary unless the cannula has been in position for a prolonged period of time and the wound edges are epithelialized

Complications. The alleged complications of tracheotomy are usually the result of unjustified delay poor surgical technic during a hastily performed *procedure* or *inadequate postoperative* supervision. *Surgical shock* is a small factor compared to the overwhelming relief experienced by the patient Even struggling children usually become quiet and cooperative as soon as the trachea is incised and the respiratory obstruction is relieved restful sleep often intervenes while the patient is still on the operating table A conspicuous *scar* is easily repaired by plastic surgery During an orderly tracheotomy a horizontal collar incision through a normal crease in the skin may be employed in place of the conventional vertical incision if a special cosmetic effect is desired

Tracheal *granulations* and *strictures* can generally be avoided by the removal of a round segment of the anterior tracheal wall and the insertion of a well fitting cannula This procedure prevents buckling and narrowing of the trachea, and discourages the formation of inflammatory granulations at the cut edges of the split cartilaginous rings The defect in the tracheal wall later closes spontaneously with a thick layer of fibrous tissue, leaving no undesirable sequelae

Pneumothorax and *mediastinal* em

physema can be avoided by strict adherence to the correct surgical technic. Specifically one must avoid a low tracheotomy lateral dissection denudation of the trachea, and tight closure of the wound around the cannula *Atelectasis* and *pneumonia* are usually the result of inadequate postoperative care and can be prevented by humidification trypsin inhalations frequent aspirations or the bronchoscopic removal of blood clots and crusts

Prognosis The operation tracheotomy correctly performed as soon as indicated, should be free from danger The prognosis in each instance depends upon the severity of the underlying pathologic process and its effective control. In any case of respiratory obstruction good results can be expected only if a patent airway is restored in time Experience has taught the author that in any doubtful case the risk of delay is far greater than the risk of performing a tracheotomy Surgical intervention cannot be expected to alter the prognosis when the patient is in extremis or after asphyxia and cardiac exhaustion have passed beyond the stage of possible recovery

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GORDON A DONALDSON, M D

9

The Management of Acute Soft Tissue Injuries of the Neck

ACUTE trauma of the neck as an entity has rarely been considered and recent interest in this subject may be another index of our age of organized specialization There are features of neck injuries, indeed, which deserve especial attention and comment and which require intimate knowledge of anatomy and accuracy of diagnosis

Because of the relatively small size and the protected position of the neck between the head and shoulders soft parts of the neck are not often injured Fig. 1B demonstrates the protection afforded by bony structures when simple acute flexion of the cervical spine is carried out as a protective measure In Fig. 1A a number of important structures are made vulnerable by extension of the neck. In suicidal attempts, missile injuries, and unheralded trauma, the soft parts of the neck are without any protection whatsoever The World Wars were productive of case reports which have been instructive in the handling of these injuries which were incurred without warning

In no other part of the body is minor surgery more likely to take on the proportions of major surgery than in the neck. Small puncture wounds of the skin may result in hematoma formation and strangulation, fatal emphysema, or extensive mediastinitis The size of the external wound and the extent of tissue damaged are rarely proportionate and many neck wounds which appear to be slight are immediately fatal or soon become so On the other hand, it may be said that if care adequate to the needs can be instituted early even the severest of wounds may be treated successfully today This places the responsibility of survival squarely on the accuracy of diagnosis and speed of treatment on the part of the surgeon in charge

GENERAL CONSIDERATIONS

Anesthesia In the face of strangulation obstruction or exsanguination, immediate tracheotomy without anesthesia is, of course, essential. Manual pressure over the bleeding points will often allow the patient's transport to more complete facilities It would seem that apart from the obvious lacerations and cuts superficial to the platysma, most perforating or penetrating wounds should be investigated under general anesthesia. Too often a minor procedure becomes major and absence of adequate anesthesia may lead to disaster Local infiltration or field block has little justification today

vious reasons should snug circular band ages around the neck be used Blood clots should not be disturbed or foreign bodies removed Emergency tracheot omy is best done with the patient in a slightly Trendelenburg position with the neck extended, to prevent further aspir ation of free blood which is inevitably present. The trachea is fixed between thumb and index finger A vertical in cision is made over the trachea in the midline from the level of the upper border of the manubrium upwards so as to include two tracheal rings A rubber metal or glass tube is inserted, and a simple bulb syringe and catheter if available, may help prevent aspiration and provide better aeration of the lungs until a hospital is reached. Transportation in the prone position further discourages accumulation of blood and mucus in the bronchial tree

The need for tracheotomy in nonperforating injuries of the neck should be emphasized. In this situation there is enough hemorrhage and edema of the false cords and arytenoids seriously to impede respiration Tracheotomy is the only means of putting the larynx at rest and thus speeding resolution of the injured area. This tampon effect is not so great in open wounds of the neck where the deep pretracheal fascia has been lacerated and released

Blood Vessels. Injuries to the large important blood vessels of the neck seldom occur The small size of the neck with respect to its exposed surface and the possibility of decreasing this ex posed surface by natural protective ma neuvers make injury to the deep-seated vessels unlikely Moreover actual lacer ations of the jugular veins or carotid ar teries are not often amenable to surgical treatment, because many patients suc cumb immediately from exsanguination, compression strangulation or aspira tion of blood into the pulmonary tree Others die as the result of concomitant damage to other deep-seated vital structures

Due to the number and size of the more superficial vessels in the neck practically all wounds bleed profusely Control of hemorrhage and reconstruc tion of vascular channels as elsewhere in the body require adequate exposure and understanding of the anatomy In general lacerations or perforations should be extended in the long axis of the vessel involved, or suspected of being involved, regardless of skin lines Under complete anesthesia in a well equipped operating room with blood replacement available, the control of hemorrhage and a careful vasculoplasty may be done Restoration of the integrity of important vessels may require cutting the clavicle, dislocation of the sternoclavicular joint, or splitting of the sternum and lateral displacement of the upper thoracic wall, as described by Churchill[3] It should be remembered that in addition to the common, internal, and external carotid arteries in the neck there are important branches of the subclavian, notably the vertebral and the thyrocervical axis with its several branches In the face of a major lacera tion control over the common carotid and the subclavian arteries may be nec essary to keep blood loss at a minimum and prevent extensive soft tissue damage In the handling of the jugular system, added friability of the vessel wall makes adequate exposure manda tory for any sort of a plastic procedure. In many instances however the venous structures are expendable

As emphasized by Lichtenstein[4] in a series of missile injuries in World War II every *effort should* be made to close

partial lacerations even though the resulting lumen of the vessel is narrowed by the suture Too hasty ligation invites serious cerebral changes due to the anoxia resulting therefrom and, in addition, there is always the hazard of thrombosis and embolism distal to the ligature Local trauma to the blood vessel wall and the presence of slowed blood flow and hypotension make an ideal medium for thrombus formation And it is doubtful, in view of the inevitable associated soft tissue damage whether the use of anticoagulant drugs to prevent thrombosis is ever safe Should complete transection of the vessel exist, careful end-to-end anastomosis using fine interrupted silk, is expedient In certain situations where vessel substance has been lost, grafting should be attempted. The long saphenous vein because of its thick wall and ready availability is perhaps a more satisfactory vascular replacement than a segment of the external jugular vein.

In the absence of distal thrombosis and embolism common carotid ligation with complete severance of the vessel can safely be done without precipitating anoxic hemiplegia In the younger group of soldiers treated by Lichtenstein this was universally successful Interference with cerebral circulation occurs most commonly and acutely from enforced ligation of the internal carotid or both the common and external carotid arteries. The gravity of the sudden impairment of blood supply to the brain is considerably increased in individuals over fifty years of age because of the coexisting arterial vascular disease In this group ligation of the internal carotid, or of the carotid bulb or of the common and external carotid carries a mortality as high as forty to sixty per cent If the patient does survive a hemiplegia frequently ensues Conley and Pack[5] have found it possible to anastomose the distal ends of the severed external and internal carotid arteries, thus permitting a continuous flow of blood through the terminal arc, sufficient to prevent arterial thrombosis hemiplegia, and death.

The venous system has a remarkable ability to adapt itself to changing needs In the head and neck communications are abundant, venous pressure is low valves are absent, and reversal of flow *easily occurs In the neck the vertebral* plexus—internal vertebral, external vertebral and intercommunicating veins—appear to afford the principal by-pass after removal of the jugular systems According to Batson,[6] this plexus in total cross section exceeds in area both internal jugular veins and it is probable that this system is adequate to provide for the entire drainage of blood from the cranial cavity Because of the availability of this drainage area it can be said that simultaneous bilateral ligation of injured jugular veins can be done provided the patient is under fifty years of age and the ligation is done at a high level. Batson concludes that "the anatomy of the venous system is favorable for bilateral jugular vein interruption, and—it would seem that there need be no great fear of ligation of both internal jugular veins when conditions demand " In the elderly sedentary patient in whom the vertebral vein anastomoses are poorly developed it may be hazardous to interrupt both internal jugular veins and a unilateral graft utilizing the saphenous vein is advisable. From the anatomical studies of Gius and Grier[7] restoration of continuity of the right jugular is usually more efficacious than grafting the left vein.

Air Passages. Vascular injuries in

the neck are not usually associated with *direct* damage to the air passage ways and *vice versa* Embarrassment to respiratory exchange may be caused in several ways In addition to the actual aspiration of blood through an open absorbable silk or wire in the perichondrium In the case of smaller wounds closure may be spontaneous, or may be accomplished by suturing overlying fascia and muscle of adjacent thyroid tissue over the defect

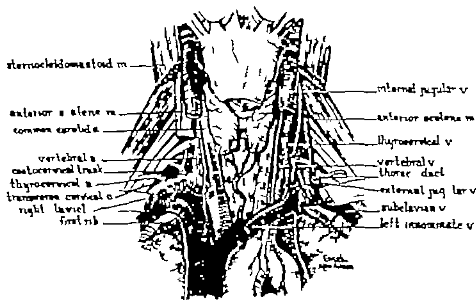


FIG 2. The important vascular structures of the anterior neck and upper thorax are shown. Sections have been cut from the jugular veins. On the left a portion of the anterior scalene muscle has been removed to demonstrate the arterial branches of the subclavian artery On the right, the venous pattern anterior to the intact scalene muscle is shown.

trachea or larynx, an external tamponade may be established by air or blood in the surrounding tissues A gradual obstruction resulting from the edema resulting from blunt external trauma makes it essential that these individuals be closely supervised during transportation to the depot of final treatment.

Should tracheotomy be necessary in the definitive care of such injuries a fresh, clean incision should be made below the area of trauma. Generally such wounds heal spontaneously on removal of the airway and there is less likelihood of fistula formation. After débridement, a careful end-to-end suture of the trachea, larynx, or hypopharynx may be carried out, placing fine non-

Neglected wounds of these structures had best be allowed to remain exteriorized, after a tracheotomy has been done, until such time as tissue reaction has subsided and plastic procedures may be safely performed

Cervical Esophagus. The recognition of injury to the esophagus or hypopharynx is a most important feature in the emergency handling of such trauma Penetrating wounds may go unrecognized for *hours* *resulting* in serious spread of infection The final depot examination of the pharynx and esophagus at the time of endotracheal intubation should precede any other procedure and it is justifiable at such time simultaneously to probe any wound

which *might* penetrate the food way The liberal use of antibiotics fails to prevent a fatal result when perforations are unrecognized and undrained Operative exploration of the cervical fascial spaces is justifiable in the absence of actual lacerations The release of closed space pressure often results in improvement of both breathing and swallowing Release of pressure and infection from the retropharyngeal space by wide drainage thus exteriorizing the esophagus is all that should be attempted in many instances while attention is directed to finding the effective antibiotic agents

Too enthusiastic first aid measures may introduce more bacteria than the object causing injury Débridement should be thorough but not wasteful of living tissue Saline irrigations should be copious accompanied by several changes of instruments and gloves Soap and water scrubbing is to be avoided

A careful three layer interrupted silk stitch closure is effective in suturing freshly injured esophageal tissue The cervical esophagus is mobile enough to allow such a suture and it is doubtful that exteriorization is necessary in wounds of recent origin Because of the straight course of the organ its contractility on deglutition unavoidable edema and the rather precarious blood supply both Eckel[9] and Lichtenstein[10] advise complimentary jejunostomy or gastrostomy in the case of any major injury A simple two-layer purse string suture placed about a catheter the inner purse string fixing the catheter to the bowel wall, is adequate. Nasal or oral gastric tubes should be avoided

Complications

The cerebral changes resulting from anoxia may respond to supportive treatment. Partial and transient obstruction to the vascular structures may not produce irreversible brain damage and oxygen and general supportive measures should be pushed for days In the case of secondary thrombosis or embolism recovery in younger individuals may be surprising

Emphysema of the mediastinum, with or without pneumothorax has long been recognized as a possible complication of surgery of the thyroid and neck. It may occur with greater frequency after neck injuries and should be suspected for some hours after open trauma Wounds of the trachea are most often complicated by severe emphysema of the deep structures of the neck If relieved early by exposure of the pretrachial fascial space, trapped air will disappear in twenty four hours Champneys was the first to call attention to this complication following tracheotomy It is rarely the result of injury to the apical parietal pleura and most often due to the sucking of air into the mediastinum by a powerful inspiratory movement, in the presence of an upper air way obstruction Eventual rupture of the mediastinal pleura into one or both pleural spaces may follow and there may be an associated subcutaneous emphysema The mortality as reported by Wiley and Sugarbaker[11] is high twenty-five per cent in unilateral and eighty nine per cent in bilateral pneumothorax. Recognition of this development, after cervical lacerations is life saving and the results of early treatment are good. Aspiration of the pleural air sealing of the neck wound, and maintenance of a free airway should be performed as expeditiously as possible Bowden and Schweizer[13] in the light of their experiences at Memorial Hospital in New York, advocate institution of water sealed intercostal catheter drainage as

a more effective and fool-proof method of aspirating the pleural spaces

Infections in the neck particularly below the level of the platysma have always been cause for real concern Because of the fact that the mediastinal structures embryologically arise in the neck and migrate into the chest, there orrhage or the "milking" effect of muscle action alone Various operative procedures have been devised to limit this spread and by drainage to the various spaces set up barriers which Nature has failed to provide [14] In acute neck infections of unknown bacterial origin antibiotic therapy should be considered only

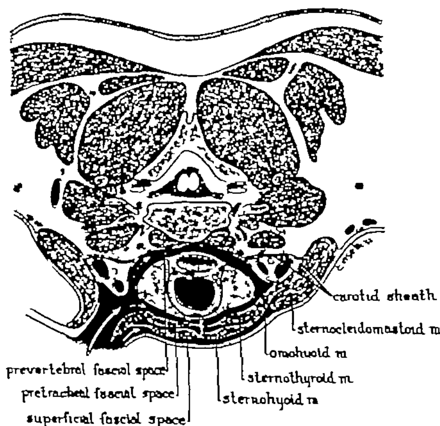


Fig. 3 A cross section drawing at the level of cervical vertebra VI, showing possible avenues of approach to the various compartments of the anterior neck. By retraction of the sternocleidomastoid muscle, the important fascial spaces may be entered and any tamponade effect released or infection drained.

are no transverse demarcations in the fascial envelopes surrounding these contained structures Infection may extend unlimited, from the base of the skull to the diaphragm, within the superficial compartment, the pretracheal compartment, or the prevertebral compartment of the deep cervical fascia. This spread is abetted by the exudative force of the infection itself propulsive force of hem- as an adjunct to adequate anatomical surgical drainage A unilateral or bilateral approach usually anterior to the sternocleidomastoid muscle, will give access to any or all of the important fascial spaces within the cervical compartment.

Neck Injuries

Suicidal. Although this method of homicide or suicide is reported to be

rarer than it was before the availability of less strenuous means of ending life, it *still occurs and unsuccessful attempts* occasionally allow for reconstructive efforts. Properly instituted treatment is particularly effective in spite of the initial devastated appearance of the wound It is reported by Hoche[8] moreover that from the psychiatric viewpoint, the prognosis in this group of individuals is not bad.

It is well known that in such a maneuver the head is thrown well back, and with it the major vessels are protected unilaterally at least, by the vertebral column The important vessels and nerves of the neck are rarely severed It is the superficial vessels which bleed so profusely and can be controlled by compression against the cervical vertebrae. The air and food passageways are most commonly cut, and this occurs at a level between the hyoid bone and the thyroid cartilage The hyoid bone may protect vital structures above, and in adults the larynx gives protection below In such a laceration if performed vigorously enough the hypopharynx is opened This may involve the anterior wall only or may carry through to the vertebral column In any event, after emergency tracheotomy at a lower level meticulous end-to-end suture under general anesthesia in a well equipped operating room is indicated The deep spaces must be drained and the superficial wound may be closed later by suture or by positioning the head and purposeful bandaging In a small series reported by Eckel from Münster jejunostomy or gastrostomy was helpful in preventing external fistula formation This is particularly so if the esophagus itself rather than the hypopharynx, is transected.

Missile Injury From World War II has come a series of excellent case reports by Lichtenstein of trajectory cervical injuries which has added greatly to our experience with such trauma Missiles may act as vascular plugs and first aid treatment should not include their removal. X ray examination for free air and foreign body is essential, and endoscopy will at times reveal an unsuspected perforation of the hypopharynx or esophagus Exploratory fasciotomy in the neck may relieve a tamponade and forestall a tracheotomy in a patient with stridorous respiration.

Human Bites These puncture wounds are not uncommon, according to Crikelair and Bates,[15] and they differ from bites of the hand in that there is no actual tissue loss in most instances. They are not as severe or disabling for anatomic reasons, and they can be safely treated as other lacerations or tissue defects Washing with soap and water débridement, saline irrigations, and primary suturing are safe Antibiotics are advantageous but tetanus antitoxin is not. Lowry reports the tetanus bacillus has never been recovered from the human mouth (See Chapter 62)

Contusions of the Neck These are borne chiefly by the trapezius muscles, due to the protective reflexes involving the neck when exposed to trauma Strains and sprains occur often in athletes, and are treated in a supportive fashion Various important sequelae of acute cervical trauma include aneurysmal dilation of various veins and arteries nerve injuries and muscle atrophy air or food way fistulae lung herniae etc It is beyond the scope of this chapter to discuss these

Conclusion

Because of the vital structures within the neck acute injuries in this area call for emergency treatment Procrastina

tion on the part of the surgeon may lead to exsanguination suffocation or late mortal sepsis Any injury of the neck is never slight enough to be neglected and on the other hand, no wound is extensive enough to be regarded as hopeless

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10

Immediate Treatment of Ocular Injuries

Two opposing sets of factors determine the frequency of the incidence of eye injuries (a) protective factors and (b) exposure factors

Protective Factors. These include the strong bony orbits which encase the eyeballs on all sides except for the anterior aspect A resilient pad of fatty tissue behind the globe maintains the forward position of the eye to provide both a wide field of vision and at the same time a soft protective cushion The extreme sensitivity of the cornea and the speed of the blinking reflex of the eyelids are of the greatest importance in preventing eye injuries

Exposure Factors. So little of human activity does not require vision, that almost everything we do necessitates positioning and maintaining the eyes fixed upon the field of action This constant exposure only accentuates the tremendous efficiency of the protective apparatus described above In general, trauma to the eyes is treated very much like trauma to other parts of the body However because of the specialized function of the eye certain aspects of tissue placement and function demand a great deal of attention and particularly careful management in the care and treatment of injuries Thus the transparency of the ocular media the precise distance between and alignment of the refractive elements of the eye in relation to each other and to the position of the percipient end organ (the retina) must all be considered of primary importance in handling these accidents. This of course, is rarely of importance in the management of soft tissue injury elsewhere Below is a list of how these disturbances may affect the end result.

1 TRANSPARENCY Corneal opacities, pupillary membranes lenticular opacities (cataracts) and vitreous opacities all may reduce vision. These opacities may consist of scar tissue, blood, hematogenous or uveal pigment, inflammatory exudates and foreign bodies Special care must be exercised to keep these to a minimum to conserve vision

2 PLACEMENT (a) Intraocular displacements include forward or backward positioning of the iris and of the lens prolapse of vitreous into the anterior chamber beneath the retina, or choroid detachment of the choroid and retina.

(b) Extraocular displacements include prolapse of iris ciliary body choroid, retina, lens and vitreous These require special management both to conserve vision and to preserve the integrity of the eye as a whole, otherwise phthisis results

One other aspect of ocular trauma de

serves special mention and that is intra ocular pressure Adequate measures are necessary to prevent hypertension (glau coma) or hypotony which so often com plicates serious eye injuries

LIDS AND ADNEXAE

The frequency of injuries to these parts makes them of great importance to the surgeon Three points should al ways be considered in the complete diagnosis of eyelid traumatism Break in continuity of lid tissues (skin orbicu laris and levator muscles and tarsus) injury to bony orbit, and injury to the globe itself Indeed careful and accu rate examination should be made of the globe before any steps are taken to repair the lids

Lacerations· Because of the lack of true subcutis, the elasticity and the very loose attachment of the skin to the underlying muscle local edema and ecchymosis following trauma are more striking in this region than in most other parts of the body Thus, relatively minor injuries very often produce marked swelling from edema and ecchymosis which readily spread also to the unin-volved side. Breaks in the skin if par allel to the palpebral fissure that is in line with the orbicularis muscle fibers result in very slight to no deformity whereas those occurring across the direc tion of muscle fibers leave deformed scars Surgical incisions of the skin of the lids, therefore should whenever possible be made parallel with the direc tion of the lid margin. Meticulous closure, layer by layer must be made of lid lacerations to insure a minimum of disfigurement. The application of cold and a pressure bandage assist greatly in the treatment of swelling. Thus, there is no exception to general surgical prin-

of lacerations of the eyelids If the l should involve the medial portion o lids the canaliculi may be severed pair by the ophthalmic surgeon becomes necessary for their restitu in order to avoid epiphora. When levator palpebrae superioris is inj extensively enough to cause ptosis the eye surgeon should be consu The indications for the administra of tetanus antitoxin are the same a wounds in general

Burns. Burns of the eyelids are aged like burns elsewhere, except care needs to be exercised to avoid tricial deformity of the lids which leads to entropion with trichiasi ectropion with epiphora

CONJUNCTIVA

Burns. Burns from heat or chem agents affect the lower conjunctiva that portion lying exposed in the palpebral fissure more often and intensely If exposure to chemical stances has occurred immediate, tinuous and copious irrigation water should be instituted for at several minutes Blepharospasm sh be controlled by the prompt instill of topical anesthetic drops (pontac butyn holocaine, or cocaine) and lids held apart with the fingers o retractors All solid particles shoul removed as soon as possible by m of cotton swabs or forceps One sh not omit eversion of the lids to ex the fornices for any such particle possible it is best to continue irrig while the mechanical removal of matter is being accomplished To a *Infection and adhesions* which in lead to the formation of symbleph or ankyloblepharon, one should an antiseptic and/or antibiotic oint

pound hydrosulfosol, to promote rapid healing and minimize scarring, may also be instilled either in an ointment or oil vehicle If the area of conjunctiva destroyed is large early grafting with conjunctival or other mucous membrane is advisable to promote rapid healing and to avoid symblepharon. The single most important step in the treatment of chemical burns is generous irrigation with water or saline No time should be wasted procuring antidote solutions which are of highly questionable value in these cases

To control edema and pain cold compresses, infrequent local use of anesthetics only when absolutely needed, and a snug pad may be employed, and if necessary codeine and aspirin by mouth should be prescribed Daily inspection is done and adhesions should be broken with a probe after the instillation of a topical anesthetic Because the transparency of the cornea is at stake the formation of adhesions may occur the *lids may become distorted so as to result* in entropion (and consequent trichiasis) or ectropion (and epiphora) the ophthalmic surgeon is to be consulted in all these cases

Lacerations Lacerations of the conjunctiva heal very quickly by themselves so that only rarely when they are extensive do they require sutures Chemosis (edema) and subconjunctival hemorrhage when they follow trauma are best treated with cold compresses and a pressure bandage Whenever protrusion of the conjunctiva prevents closure of the lids frequent applications of antiseptic or antibiotic ointment pressure dressings are indicated

Foreign Bodies By far foreign bodies in the conjunctival sac are the commonest of eye injuries Successful treatment depends entirely upon the ability of the physician to find them Good focal bright illumination supplied by a pocket flashlight is indispensable, as is adequate exposure of the palpebral conjunctiva and of the fornices. Eversion of the upper eyelid, therefore is imperative for the search in addition to other manipulations of the lids Because there is a sulcus in the tarsal conjunctiva a short distance above the lid margin, it is not surprising that it serves to trap a majority of the loose conjunctival foreign bodies which the patient and his friends never seem to locate Once found it is a simple matter to wipe out the foreign body on the tip of a moist cotton swab or merely to wash it out by irrigation with a stream of water An ear syringe or even an ordinary 5 cc. glass syringe serves this purpose well

CORNEA

Abrasions. Symptoms varying from a mere suspicion on the part of the patient of scratchiness or foreign body sensation to excruciating pain accompanied by profuse lacrimation photophobia and blepharospasm characterize this extremely common injury In general, the larger the abrasion, the more severe *is the complaint, although at* times the minutest of epithelial dissolutions give rise to an inordinate amount of discomfort to some patients with an *extremely low threshold for pain* As with foreign bodies of the conjunctiva, proper illumination is essential to the discovery of abrasions A break or irregularity in the mirror (specular) reflex as the flashlight is held close to and moved across all areas of the cornea is a reliable sign but can be easily missed by the inexperienced observer

Small abrasions disturb the light image insufficiently for even the expert to detect. In such cases it is necessary

to use a drop of two per cent fluorescein which is permitted to remain in the conjunctival sac for a moment or two before flushing it out with water. The dye diffuses very readily through the water imbibed by the subepithelial corneal tissue which is exposed at the site of the abrasion. In this manner the abraded area "stains." It should be remembered that droplets of mucus lying on the cornea may also hold the dye but these move whenever the patient blinks his eye. The dye appears green in the diffused state at the site of the abrasion, which remains stationary after the lid passes over the cornea. Only when the cornea has been examined under magnification and with the aid of brilliant focal illumination as furnished by means of the slit lamp or biomicroscope can one be sure of the absence of minute abrasions which may cause the symptoms.

Abrasions if small require only antiseptic or antibiotic drops several times a day and the use of a corresponding ophthalmic ointment at night. Larger ones may require bandaging, or at least the wearing of dark glasses. The instillation of mydriatic, cycloplegic drops (homatropine or atropine) must be done in those cases of large or persistent abrasions which give rise to signs and symptoms of iris or ciliary body irritation, as shown by ciliary injection or changes in the aqueous.

Certain types of corneal abrasions particularly those caused by sharp deeply cutting agents, *e.g.*, finger nail, paper edge, twig, or glass, occurring in susceptible individuals cause a condition known as recurrent corneal erosion. Very often the diagnosis is made difficult by the failure of the patient to recall a previous eye injury since it may at the time have been trivial and have healed promptly. However, if the history obtained is that of sudden acute pain and tearing of the eye, characteristically when awaking from sleep and especially when several such episodes have occurred at varying intervals in the past, the physician should always consider recurrent erosion as the most likely diagnosis. This is confirmed in many cases by the appearance of superficial epithelial infiltrates collected in a cluster or of an area of the cornea denuded of epithelium. In both these two instances coloration with fluoresceine is obtained. Very often one must resort to the use of the slit lamp to demonstrate the lesion or the use of the opthalmoscope employing a plus four diopter lens in the instrument which is held twenty five centimeters from the patient's eye. The latter procedure is carried out in a darkened room, viewing all areas of the cornea in turn by using the red-reflex of the pupil as a background. Treatment consists of application of ten per cent boric acid ointment for an extended period of time on retiring. For larger erosions or those failing to respond to night time lubrication, cauterization with twenty per cent trichloracetic acid should be performed after instillation of a topical anesthetic. This is best done under the slit-lamp.

Foreign Bodies. These may simply lie on the corneal surface, they may be embedded, or they may penetrate to different depths of the stroma. As with conjunctival foreign bodies, they constitute the commonest type of corneal injury. When small in size they are difficult to find. Good bright illumination which can be focused on the corneal surface as a spot, streak, or slit must be available for localization. This not only helps in finding the foreign body but also in estimating the depth of penetra

tion into the corneal substance Included among the searching technics are the use of fluorescein, as described in the discussion of corneal abrasions, and various types of illumination employed by the ophthalmologist. When the pocket flashlight is used it should be brought close to the eye to facilitate observation of the specular surface reflex. It is irregular or distorted when it lies in the field of the foreign body The shadow on the iris which moves with movement of the light source assists in localizing a corneal foreign body A loupe or magnifier must be available to find particles of small size

Once the foreign body is found, the cornea is anesthetized with the appropriate *anesthetic drops and the offending* substance then may be wiped away with a moist small swab The exercise of meticulous care is imperative to avoid additional trauma to the delicate epithelium. Thus, only two or three gentle attempts with the swab should be made If this should fail a sharp small gauge hypodermic needle mounted on a 1 or 2 cc. glass syringe barrel must be used to pick out the foreign body For safety this requires the experience illumination, and visual aids possessed only by the ophthalmologist. The best rule to be followed by other surgeons when two or three wipes with a small moist swab fail to dislodge the foreign body is to seek the assistance of the oculist.

After the removal of a ferrous particle from the cornea there always remains a rust ring which often proves to be as irritating and as much of a hindrance to healing as the foreign body itself This rust ring frequently must be dissected out with a small sharp pointed cutting instrument, again by the eye surgeon. As a rule metallic foreign bodies are poorly tolerated when embedded or

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Perforating Wounds. M
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If the wound is made by a larger object, the corneal opening serves as the point of exit of some intraocular substance, leading to collapse of the anterior chamber Usually this consists of iris tissue in the form of a prolapse In more extensive wounds, vitreous may escape especially if the lens should be dislocated. These wounds must be sutured to render them water-tight after excision of any incarcerated iris tissue or vitreous has been done so as to permit direct contact of the wound edges. Air or saline may be injected into the anterior chamber to prevent anterior synechiae to the posterior aspect of the perforated cornea. This repair is done by the ophthalmic surgeon. Deep ruptures of Descemet's membrane and of the stroma may be seen following severe blows with a blunt object or a blast. Treatment is medical for the alleviation of traumatic iritis and cyclitis If hyphemia should occur and bleeding continue to fill the entire anterior chamber then a so-called black ball hemorrhage ensues The color is no longer red but black, and glaucoma results This may necessitate evacuation of the blood from the anterior chamber through a paracentesis or keratocentesis opening In cases where glaucoma with hyphemia persists for a long time and in cases where endothelial dystrophy previously existed, hematogenous pigmentation of the cornea may follow A large central disk of brown and yellow discoloration appears, which may persist unchanged, or after a long period of time decrease in size or entirely disappear

SCLERA

Contusion Subconjunctival hemorrhage, luxation of the lens, tears in the iris, choroid and retina, and hemorrhage into the vitreous and anterior chamber are evidences of intraocular injury by contusion without perforation of the sclera. Cold compresses analgesics, covering the eyes and absolute bed rest are the treatment.

Perforation When a severe blow increases the intraocular pressure high enough suddenly the sclera ruptures at its thinnest region. This occurs most commonly in the region of Schlemm's canal just posterior to and concentric to the limbus Evidences of perforation include hypotension the anterior chamber is shallow to absent or may be filled with blood, and finally prolapse of uvea or vitreous at the site of the wound. Small sharp objects conversely may penetrate into the eye's interior through the sclera and leave absolutely no sign as to the point of entry or other ocular disturbance except for the presence of the intraocular particle

If the injury is obviously too extensive to afford any possibility of salvaging the eye and this opinion is confirmed by another eye surgeon, immediate enucleation should be undertaken. In other cases the wound site is freed of all prolapsed tissue by abscission and the scleral opening is closed by sutures Finally the conjunctiva is separately closed with sutures Chemotherapy and/or antibiotic parenteral therapy is begun. Locally antiseptics and antibiotics are used together with atropine. In all cases careful and long observation of the other eye is pursued for any signs of sympathetic ophthalmitis Atropine, salicylates, parenteral foreign protein therapy local and even oral cortisone

are administered if this dreaded complication should arise

LENS

Opacities. Traumatic cataract complicates many kinds of eye injuries whether they be penetrating or not. Unlike senile cataract the process of maturation may be very rapid and become complete in only a few days In other cases it too may require considerable time for complete opacification. Cataract formation indicates that the lens capsule has been broken or damaged at the time of the injury If only a small opening is present the opacity may remain small and limited at the site of the rupture of the capsule Typically the concussion variety of cataract is seen to lie beneath the posterior capsule and assume a rosette form when viewed under magnification As the cataract spreads, the entire lens fiber structure becomes opaque

Only when the opacity is fairly large dense and situated in the pupillary area can it be seen by reflected light, *e g* with a flashlight Otherwise, it can be seen only with the ophthalmoscope The best procedure for this examination is to place the patient in a dark room dilate the pupil with a mydriatic, stand about one meter away and look through a plus one lens in the ophthalmoscope In this manner the red reflex of the fundus forms a perfect background against which an opacity which fails to transmit light from the ophthalmoscope light can be most easily observed. Only continued periodic follow-up examinations will reveal progression of the lesion in mild cases If as the cataract matures, intumescence by imbibition should occur secondary glaucoma ensues and the cataract must be removed. Otherwise the decision as to the removal of the cataractous lens depends upon the vision of the uninjured eye and the kind of visual task the patient s work entails

Foreign Bodies. When foreign bodies are large or metallic not only is the transparency of the lens tissue destroyed but often the eyeball itself is endangered However small nonirritating ones which have caused only small perforations may cause only slight opacities which do not change with time The management of lenticular foreign bodies does not differ from that followed in other cases of intraocular foreign bodies

Luxations Small displacements of the lens are termed subluxations This complication may result from relatively severe blows, especially the snapping or whipping kind In such instances the following signs indicate partial or incomplete lenticular dislocation

1 The depth of the anterior chamber may be greater in one sector than in another

2 The iris may be tremulous when the eyeball is suddenly moved Iridodonesis is thus present

3 The edge of the lens may be seen in the pupil This is best seen under mydriasis

4 A bead of vitreous may prolapse through the ruptured zonular fibers and present itself anterior to the pupillary border lying on the lens capsule or even on the iris itself

The treatment is conservative and depends upon attendant secondary findings *e g* glaucoma is treated with miotics and iritis requires cycloplegic medication

Complete posterior dislocations of the lens produce the typical clinical picture of aphakia characterized by a deep anterior chamber iridodonesis, and the absence of the lenticular Purkinje reflex. The latter is a small highlight dimmer

than the corneal reflex and lying posterior to it. With movement of the flash light it moves in a direction opposite to that of the light source In aphakia it cannot be demonstrated The displaced lens in these cases lies posteriorly in the vitreous body and because of gravity is most often found lying below ophthal moscopically In anterior dislocation the lens is found in the anterior chamber In both types of luxation glaucoma is very common and very difficult to treat. Often extraction of the lens must be done if medical treatment with miotics and vasoconstrictors applied locally should fail In time, the lens becomes cataractous if left in the eye When the sclera ruptures from blunt force the lens may be extruded and lie beneath the conjunctiva with or without a vitre ous prolapse

VITREOUS

Displacement As a result of perforation of the cornea or sclera, vitreous prolapse or loss from the eye often takes place Its presence between the lips of the wound prevents healing and for this reason it must be excised in the toilet of the wound at the time of its repair When vitreous loss is suffered in quan tities less than two or three cubic centi meters it is replaced with fluid and may not be fatal to either the integrity of the globe or to the vision. Losses greater than this are apt to lead to phthisis bulbae Vitreous may also be displaced intraocularly thus it may prolapse into the anterior chamber it may be found to lie in a subretinal, subchoroidal, or even subconjunctival space

Opacities: Disturbances in the optical homogeneity of the vitreous may result from hemorrhage originating from a break in the vessels of the iris, ciliary body choroid, or retina. Inflammatory products mixed with pigment particles may invade into its substance from a traumatic uveitis Foreign bodies them selves may be the opacities lying in the vitreous body as well as the lens when it is dislocated posteriorly Most foreign bodies are poorly tolerated, unless encapsulated and require immediate if not eventual removal to preserve vision These opacities of course are seen usu ally only ophthalmoscopically

IRIS AND CILIARY BODY

Lacerations Tears of the iris from trauma may involve the sphincter and cause irregular pupillary dilatation or notching of the border of the pupil. Flattening of a sector of the pupil is caused by a tear at the iris root or dis insertion from the ciliary body called iridodialysis and may be accompanied by a prolapse of the vitreous through it whenever the lens zonule is ruptured. These injuries are so commonly complicated by hemorrhage which fills part or all of the anterior chamber that only after absorption of the blood has occurred can the diagnosis be made Treatment consists of cold compresses, cycloplegic drops, eye bandage and bed rest.

Displacements Perforating wounds of the cornea with loss of aqueous, swelling of the lens in traumatic cataract, or herniation of the vitreous through the zonule into the posterior chamber will displace the iris forward. Posterior scleral rupture with loss of vitreous, posterior dislocation of the lens and even anterior dislocation of the lens into the anterior chamber in front of the iris will displace the iris backward. The latter type of displace ment also occurs in severe hypotony due to trauma This may be associated with detachment of the retina and choroid.

patient put to bed in such position as to have the region of greatest detachment dependent The object of surgery is to evacuate the subretinal fluid seal the retinal hole or holes and create scars by diathermy to the sclera binding the retina to the choroid and sclera

OPTIC NERVE

If the optic nerve is severed or injured anterior to the point of entry of the central artery the fundoscopic appear ance produced is due to interruption of the flow of arterial blood The retina is pale except for the cherry red foveal spot. The retina is so thin in the central macular region that even when edematous the choroidal red shows through. If severance occurs posterior to the entrance of the central artery optic atrophy as evidenced by pallor of the disk develops subsequently Other types of injuries may cause evulsion of the optic nerve from the eyeball

Most injuries are not by foreign bod ies but rather by blood or fragments of bone encroaching upon the optic canal in cases of skull fracture. Hemorrhage inside the optic nerve sheath (a subdural hemorrhage actually in the optic canal) may occur with or without demonstrating a skull fracture. These give rise to papilledema and later optic nerve atrophy

Treatment in these cases is of no avail. In all cases of optic atrophy or injury to the central artery prognosis is poor and visual loss is permanent. Papilledema on the other hand, may produce no or little loss in vision and this may im prove if no atrophy follows the subsi dence of the choking of the disk.

ORBIT

Foreign Bodies Seventy five per cent of orbital foreign bodies enter by way of the inner canthus and proceed along the nasal wall to various depths The other routes of entry in order of frequency are the outer canthus above below and through the globe The size of the foreign body determines the severity of symptoms so that the patient may have none whatever or suffer great shock or pain Examination should be careful to reveal the point of entry either in the lids or conjunctiva. The eyeball may be undisturbed or pushed to one side and be more or less prominent from retrobulbar escape of fluid and blood (traumatic exophthalmos) Ocular symptoms may be absent. If not, they consist of reduction in vision from pressure or injury to the globe or optic nerve and diplopia from disturbance in the position of the ocular axes The latter may be the result of the me chanical displacement by the foreign body effusion, or hemorrhage or the result of injury to the extraocular muscles or their nerves If the momentum of the foreign body is great enough because of its size and velocity it may bore through the orbital walls, fracturing them to enter the brain or nasal cavity Small objects may pass through the optic canal or superior orbital fissure to gain direct entry into the cranial cavity Localiza tion in all cases is by radiography

If the foreign body is aseptic or its sepsis controlled by treatment it may be left undisturbed in the absence of symptoms without causing future difficulty However suppurative processes produc ing orbital cellulitis phlegmon of the orbit, periostitis caries and necrosis of bone may occur otherwise in septic cases The usual general surgical treatment is followed. In those situations where eye symptoms are present or if the foreign body requires extraction the ophthalmic surgeon must be consulted Great care must be taken in the surgical treatment

of these injuries to prevent further injury to the levator muscle of the upper eyelid, the extraocular muscles and nerves the optic nerve and the eyeball In serious cases, adequate exposure of the orbit and its contents by resection of the outer wall of the orbit may be necessary This operation (Krönlein operation) is also done to remove particles lodged in the sphenopalatine fossa. Because of late changes and possible eye damage in most of these cases it is advisable to have an ophthalmological examination

Prognosis is dependent upon (a) direct damage on entering or removal of the foreign body (b) presence of sepsis (c) presence of inflammatory and later cicatricial changes

Hemorrhage: Exophthalmos after injury points to the presence of a retrobulbar hemorrhage. If proptosis is extreme then laceration of orbital contents or fracture of its wall should be suspected The blood may seep forward to collect under the conjunctiva and the lids as an ecchymosis Visual symptoms may be absent or the patient may experience loss of vision from pressure or damage to the optic nerve and diplopia from damage to or impairment of the function of the extraocular muscles It is surprising to find very severe exophthalmos without any change in the fundus picture However damage to the optic nerve from compression or laceration may show a choked disk, optic atrophy or occulsion of the central retinal artery Therapy consists of cold compresses and a pressure bandage

Orbital Rim Simple contusion of the soft parts from falls and blows are extremely common. This results in the common black-eye from the subcutaneous swelling and collection of blood beneath the skin of the lids Often it may spread to involve the fellow eye At first iced compresses and a pressure bandage are applied later hot compresses may aid in resorption of blood and discoloration.

The horizontal lacerations of the upper outer part of the brow extending as a rule close to the bony orbital rim present a picture very often seen after falls or blows Although the edges of the wound are bruised, infection is not rare. The edges of the wound are trimmed and closed with sutures If it is infected, drainage should be encouraged by the usual surgical technic

In more severe injuries to the orbital rim, particularly in children when the bones are thinner fractures of this region may be seen If accompanied by a fracture into the frontal or ethmoid sinuses emphysema of the lids and periorbital region occurs Swelling is then marked and crepitation on digital palpation is characteristic and unmistakable Removal of completely detached fragments and in some cases the use of wires or nails to replace them must be undertaken

Fractures of the Orbital Walls: These may be classified as (a) Direct isolated fractures (b) Radiation fractures from extension of those of the skull or facial bones (c) Isolated indirect fractures from contre-coup The clinical signs may include subconjunctival, palpebral, and retrobulbar hemorrhage or emphysema proptosis with or without disturbance of ocular motility loss of vision with or without fundus changes Diagnosis depends upon the history the clinical signs just enumerated but most of all upon x ray demonstration of a fracture. The inaccessibility to digital palpation makes crepitation and abnormal motion of the fragments often difficult to detect and because of the great danger of injury to the vital intraocular contents it is more advisable to omit this part of the examination altogether and to

depend upon the radiological findings for diagnosis The position of the fracture may further be deduced from the character of the signs and symptoms present, *e g.*, fractures of the roof into the cranial cavity may be associated with brain injury fracture at the apex of the orbit may injure the optic nerve fractures into the sinuses produce emphysema.

(1) Fracture of the Lateral Wall Injury occurs usually from the temporal rather than from the orbital aspect. Crepitation is often present. The associated injuries occur to the eyeball, the orbital muscles vessels, and nerves. The occurrence of corneal necrosis (neurokeratopathy) probably results from involvement of the ciliary ganglion and nerves as well as to the long posterior ciliary vessels.

(2) Fractures of the Medial Wall The thin ethmoid lamina papyracea and lacrimal bones are either readily directly fractured or connected with fractures radiating from the base of the skull Bleeding from the nose and emphysema of the lids and orbit are pathognomonic.

(3) Fractures of the Floor Direct fractures by foreign bodies or those radiating from fractures of the maxilla, malar bone and base of the skull from a blow on the face make up this group Symptoms include loss of sensation in upper cheek, lip and gums emphysema, bleeding from the nose (involvement of the antrum) and inferior displacement of the eyeball

(4) Fractures of the Roof Direct fractures when isolated are produced by penetrating foreign bodies, and radiating fractures arise from the vertex and the frontal bone usually Symptoms of concussion, brain damage (bradycardia, vomiting, convulsions hemiplegia) proptosis and suggillation of the lids amaurosis all attest to the severity of the fracture at this site Emphysema from communication with the frontal sinus and the appearance of cerebrospinal fluid from the nose and ears indicate a basal fracture Except for the special management of foreign bodies, these injuries are treated as fractures of the base of the skull.

(5) Fractures of the Malar Bone The characteristic flattening of the malar prominence, pain on chewing, and the detection of crepitation with bleeding from the nose and mouth make up the diagnostic findings of these fractures.

(6) Fractures of the Superior Maxilla These like malar fractures usually result from direct blows and less commonly as radiations from orbital rim or basis cranii fractures. As a rule it is associated with breaks in the malar nasal, ethmoid, lacrimal bones, and those of the base of the skull and mandible The most diagnostic sign is loosening of the jaw with the other signs of fracture.

Treatment In the treatment of orbital fractures, foreign bodies and badly fragmented bone particles which cannot be replaced are removed If the eyeball is severely damaged, this too should be enucleated, leaving whenever possible an intact conjunctiva lined socket for the fitting of a prosthesis Infection is treated as usual both medically and surgically It is perilous to probe or irrigate the deeper tissues Exposure of the orbit can be achieved by an incision just below the brow by resection of the zygoma (Krönlein approach) by a generous external canthotomy and incision of the conjunctiva in the upper lower or temporal fornix. Replacement of fragments can be secured by means of wire sutures, nails, screws, or even bandaging

Traumatic Exophthalmos. Bleeding behind the globe and forward displacement of bone fragments give rise to

this complication of orbital injuries Of special interest is pulsating exophthalmos, usually due to an arteriovenous aneurysm of the internal carotid artery and the cavernous sinus or less often aneurysm of the ophthalmic artery The visible pulsations and audible stethoscopic bruit are pathognomonic The onset of the symptoms may appear soon after or months after the time of trauma. These include severe pain in the eye swelling of lids and chemosis marked proptosis of the globe usually down and out which is increased by bending over coughing or other physical exertion noises in the head so that diplopia occurs. By pressing on the common carotid artery the symptoms may be reduced and made to disappear From direct pressure paralysis of the abducens oculomotor trochlear and the ophthalmic branch of the trigeminal nerve are produced. Treatment consists of pressure on the carotid artery or even tying it off in the neck. In some cases this procedure may have to be performed bilaterally At times it may be advisable to ligate the ophthalmic vein or resect the aneurysmal varix in the orbit which may be approached through an incision below the brow or *via* the Krönlein operation. In all cases of exophthalmos one should not neglect to protect the cornea by the frequent application of oily drops or ointment. If this should fail adequately to keep the cornea moist, a tarsorrhaphy (suturing of the eyelids) may be necessary

Traumatic Enophthalmos: This follows either absorption of the orbital fat, the contraction of scar tissue within the orbit, or from a large defect in the orbital bone case Phthisis bulbae indicates shrinking of the size of the eyeball and in this circumstance enophthalmos is purely secondary to reduction in the volume of the eye rather than to its retraction or retroposition.

Extraocular Muscles: Paralysis of these muscles may be due to (a) Lesion in the orbit such as hemorrhage infection laceration, or nerve injury (b) Lesion of the nerves at the base of the brain in the superior orbital fissure (c) Lesion of the nuclei in the brain stem

The closer to the apex of the orbit the lesion is located, the more likely more than one muscle will be affected. The incidence of involvement in order of frequency is abducens oculomotor trochlear facial, and trigeminal nerves. Prognosis is usually favorable and treatment for this condition is symptomatic

11

Acute Postoperative Parotitis

SINCE 1940 the rapid decline in the incidence of postoperative parotitis has categorized it as a surgical inheritance of days past rather than as a frequently seen clinical entity The eradication of this complication is a tribute to the progress characteristic of modern medicine and surgery Formerly postoperative parotitis was a serious complication associated with a high mortality

A review of the literature reveals that in one survey the mortality rate varied anywhere between thirty-nine and fifty nine per cent.[1 4 5,10] From this study it can be realized that it is a complication worthy of prevention

Etiology In patients undergoing major gastrointestinal surgery the danger of acute parotitis is more imminent. This is due to the absence of food intake (mastication) and the rapidity with which these patients become dehydrated

Dehydration results in concentration and stagnation of salivary secretions This state is excellent for the development of an infection, especially in the vicinity of the oral cavity which contains more organisms than any other organ or cavity of the body

The most frequent organism found in acute parotitis is the *Staphylococcus hemolyticus* Other organisms are *Streptococcus hemolyticus Aerobacteria aerogenes* anaerobic streptococci and other pathogenic organisms Vincent s organisms are often present in the culture taken from a parotid gland infection but it is doubted that the Vincent organisms alone (without streptococci or staphylococci) would result in acute parotitis Vincent s organisms are found in symbiosis with the various strains of cocci

These organisms usually become active when the oral cavity becomes "dry" secondary to dehydration With the "dry" mouth is an associated poorly-secreting parotid gland, due to concentration and stagnation within the gland itself This permits an easy passage from the mouth into Stensen s duct and then the organisms find an excellent culture medium in the gland itself Factors predisposing to the complication of acute postoperative parotitis are

1 Geriatric surgery (extensive procedures in the aged)

2 Dehydration from any cause including fever

3 Excessive administration of atropine and similar preoperative medication

4 Infections in and about the mouth (especially alveolar abscesses) and dental caries.

5 Participation in the alarm reaction

This last predisposing factor is emphasized by a recent publication which maintains that organs abounding in nucleic acid (parotid gland in this discussion)

have a marked and constant histologic participation in the alarm reaction [2] This knowledge is based upon experimental work performed on rats These investigators believe that in the postoperative state, which we know is influenced by the alarm reaction there is a lowered resistance of the salivary glands to infection.

Clinical Picture· In the production of acute postoperative parotitis the initial complaints are sudden pain and tenderness anterior to the ear (over the parotid gland) Swelling then commences associated with fever leukocytosis and difficulty in opening the mouth. With the progression of the infection within the parotid gland, pus enters the mouth through Stensen s duct. As the infection becomes more severe there is an increase in the size of the parotid gland with a concomitant increase in the pain and tenderness Usually the infection is confined to one gland only During my residency training (before the days of the broad spectrum antibiotics) four cases of this type of complication were seen on one service none was bilateral. All these patients were elderly men who had undergone gastrointestinal surgery

Acute parotitis in itself rarely causes death However its occurrence indicates a serious debility existing in the patient to combat infection. Postoperative parotitis therefore is a beacon indicating a prolongation of morbidity or a warning that mortality can occur Prior to the advent of chemotherapy and the antibiotics, therefore this complication was associated with a high mortality—especially in the geriatric age group

Treatment. As in all diseases the best treatment is to prevent its occurrence Fortunately the prophylactic therapy against postoperative parotitis resides in the great advances made in anesthesia and the adequate preoperative preparation of the patient about to undergo surgery (intravenous fluids blood etc.)

When this complication is recognized the following therapeutic measures are among the surgeon s armamentarium

1 Radiation therapy

2 Arsenicals (for Vincent s organisms)

3 Lugol s iodine (orally and topically)

4 Dilatation of Stensen s duct with intraductal injections of iodized oil, sulfa drugs and the antibiotics.

5 Systemic administration of the broad spectrum antibiotics

6 Incision and drainage.

Of all the methods mentioned, the most efficacious is to administer the broad spectrum antibiotics. Preference is given to terramycin and aureomycin

It has been reported that antibiotics may be instilled directly into the parotid gland *via* Stensen s duct [11]

In spite of the administration of the antibiotics and other measures *it may* become necessary to employ *surgical* measures to effect a cure When the suppurative process becomes *circumscribed* with or without fluctuation to simulate an abscess, incision and drainage of the area are necessary for the relief of pain as well as to evacuate the pus It is advisable to leave the wound open and to pack the area with aureomycin packing for twenty four or forty-eight hours This not only allows an exit for the pus but also results *in the local instillation* of aureomycin which is eliminated from the gauze pack into the wound.

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SECTION II

EMERGENCIES ENCOUNTERED IN THE T

BERNARD J FICARRA, M D

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Acute Breast Abscess

ALTHOUGH chemotherapy and the anti biotics have been great contributions to the eradication of surgical infections, there is a type of infection that almost always demands surgical evacuation of the infected area This inflammatory process is breast abscess The early stages of this type of abscess are so often undetected that when it is in evidence the antibiotics and local therapy are ineffectual. Surgical drainage, therefore becomes a necessity for immediate cure Early diagnosis of breast abscess would probably result in a satisfactory eradication of the inflammatory process by the proper antibiotic given in maximum therapeutic dosage. In this discussion interest centers about those patients who develop a true acute breast abscess

Etiology· Breast abscess is found almost exclusively in adult women More specifically it is seen most commonly in lactating women during the postpartum period. The pathway of entrance into the breast may be from cracks in and about the nipple From the nipple the invading organism follows the lactiferous ducts and thus enters the breast parenchyma Milk is an excellent culture medium for the bacteria. The various staphylococci are the commonest organisms found. Less frequently the streptococcus is the offending organism

An abscess may occur in the non-lactating breast. In such cases it is hematogenous in origin and has the same significance as an abscess occurring in the deeper tissues of any other region of the body A solitary breast abscess is not unusually seen as a manifestation of uncontrolled diabetes mellitus

Abscess of the breast may occur as the result of trauma Following a blow to the breast a hematoma may develop Blood is another excellent culture medium and an abscess may form at the hematoma site Rarely does an acute breast abscess arise as an extension from empyema or osteomyelitis of a rib

Clinical Picture· In the incipient and early stages of acute breast abscess the only symptom is pain in the breast. Tenderness elicited by palpation is a subsequent early complaint An abscess may develop in a patient with a known painful fissure or crack in the nipple When the inflammatory process increases the complaint of pain, which corresponds to the inflammatory spread, likewise becomes intensified The tenderness similarly becomes more marked With the intensification of the pain its radiation occurs often toward the axilla where tender enlarging axillary nodes may be felt. A rise in temperature follows the dissemination of the inflammation. It may rise to 103 F (39.5° C.) with or without a chill and/or sweating. At this

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DIAGNOSIS OF ACUTE BREAST ABSCESS AS TO LOCATION

Location	Supramammary (Subcutaneous-Abscess)	Intramammary (Parenchymatous-Abscess)	Submammary (Retromammary Abscess)
Shape of Breast	Breast substance not involved Projection of abscess under skin.	Breast usually enlarged *in toto* When process advanced prominence noted in abscess area.	Breast appears to be enlarged, hemispherical and projects from thorax.
Consistency	Unchanged	At first, hard, indefinitely outlined mass in breast Later hardening of larger part of breast or entire breast.	Entire gland feels symmetrically solid.
Rate of Onset of Inflammatory Signs	Rapid, skin inflamed on first day early palpable fluctuation.	Slow Skin unchanged at first, later becomes fixed, edematous, reddened. After many days may perforate.	
Site of Fluctuation	Usually in region of areolar	Usually in lower quadrants (especially lower outer quadrants)	Usually in circumference of gland, below (in dependent portion) external.
Tenderness	Only over swelling	Entire breast sensitive to pressure· markedly sensitive over infiltrated area.	Tenderness often absent when present it is diffuse· when fluctuation is present there is tenderness over this area.
Pain	Mild	Severe	Mild

stage the involved breast is red and fluctuation becomes discernible

Pathology The abscess formed is no different from any other type of abscess caused by either the staphylococcus or streptococcus From an anatomic viewpoint acute breast abscess occurs in the following locations

1 In the subcutaneous tissue of the areolar when it is called a subcutaneous abscess.

2 When the abscess arises in the breast parenchyma, usually arising from a small painful fissure or crack in the nipple it is termed a parenchymatous abscess

3 If the abscess develops between the breast proper and the pectoralis major muscle it is called a retromammary abscess

Treatment: When an abscess has formed, surgical incision and drainage will relieve the discomfort and systemic malaise If incision is not performed, a spontaneous break through of the abscess may occur With the formation of a true abscess it becomes evident that conservative measures have failed.

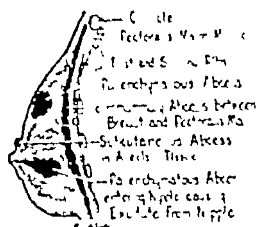


Fig. 1

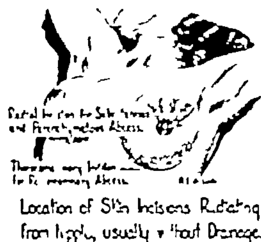


Fig.

Proper incision and drainage of the abscess affords almost immediate relief to the patient. This salubrious effect is reflected in a fall in temperature, a cessation of chills, and a diminution in the local pain and tenderness.

Breast incisions for the relief of an abscess should be radial in type whenever possible. This type of incision will avoid injury to the lactiferous ducts. In subcutaneous abscesses a rubber tissue drain may not be employed if it is not an extensive process. For the deeper abscesses, the parenchymatous and retromammary type, a drain is efficacious. It may remain *in situ* for twenty-four to forty-eight hours and then be removed. On occasion, a second drain may be necessary after removal of the initial drain. This is especially true in retromammary abscess. Following proper incision, healing is by secondary intention with obliteration of the abscess cavity. Because of the rich vascularity of the breast tissue healing is usually rapid and without undue complications.

MILTON SILLS LLOYD M D

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Foreign Bodies in the Air and Food Passages

THE scope of this chapter is limited to emergencies which arise because of foreign bodies in the air and food passages It is, therefore, not intended to be a complete text on the subject of foreign bodies and their removal For a more comprehensive discussion of these problems covering the entire field of foreign bodies in these areas the reader is referred to the several standard text books already in existence It should be made clear however that all foreign bodies in the air and food passages although not emergencies require prompt treatment, except metallic or other insoluble objects already resident for long periods of time in the lungs. "Death lurks behind every foreign body" is an aphorism which should constantly be kept in mind. The recommendations herein set forth are those which the writer has found valuable in his personal experience and which in his opinion, are not adequately covered in the standard texts They are therefore, subject to modification by the experience of others

The degree of emergency in the treatment of foreign body cases will depend upon one or more of the following factors

(1) Obstruction to breathing.
(2) Obstruction to swallowing.
(3) Nature of the foreign body
  (a) Sharp-edged or pointed (*i e* glass wire pins etc.)
  (b) Likely to produce rapid local reactions (*i.e* peanuts, meat, etc.)

Foreign bodies are seen mostly in children or elderly people. Foreign bodies in children are their toys old people are the toys of their foreign bodies.

These accidents are all easily avoidable and yet there are probably several hundred deaths annually in this country from open safety pins alone. Although the following precautions should be addressed to the lay public it may be worthwhile to set down here a few rules which, if observed would prevent most of these accidents

(1) Children should never be given toys which are small enough to be placed in their mouths.
(2) Toys should never have detachable parts small enough to be placed in children s mouths.
(3) Objects small enough to be placed in children s mouths should not be left within the reach of children
(4) Children should not be left in the care of other children if the

latter are under the age of thirteen years

(5) Safety pins whether in use or out of use should never be left open

(6) False teeth should never be worn at night or during sleep



FIG. 1 Posteroanterior view of chest showing collapse of left lung of a man who aspirated stomach content during an emergency general anesthesia Immediate removal of the obstruction is indicated

(7) Broken or improperly repaired dentures should not be worn even in daytime

(8) Removable bridges should not be worn at night

(9) People who wear false teeth are only half able to sense the presence of foreign bodies in food and hence should be doubly cautious

(10) The practice followed by some working people of holding a reserve supply of tacks pins etc in the mouth is hazardous

(11) The principal sources of foreign bodies in food are

(a) Bone fragments made in quartering meats

(b) Steel wool and other metals used for cleaning

(c) Fragments of food or drink containers made of glass with mechanically sealed covers

(d) Stomach content inhaled during anesthesia (Fig 1)

Diagnosis The diagnosis of foreign bodies in the air and food passages is made by the history and by the physical and x ray examinations

HISTORY As much information as possible should be gleaned regarding the manner of the accident and the nature of the object (Whenever possible a duplicate foreign body should be obtained for study in relation to the problem involved) Information brought forth by children is often more important than that provided by their parents and should never be ignored

The physiological fact that the respiratory mucosa is very tolerant to a foreign body at rest must be kept in mind

If a patient gives a history of losing something from his mouth during sleep (teeth dentures or a free object) he should never be dismissed without a careful examination including fluoroscopy and x rays of the lungs

PHYSICAL EXAMINATION One of the most important physical signs in the examination of the lungs is a shift of the trachea to the left or to the right Very few clinicians however learn to elicit it expertly It can be detected by inspection since the normal groove between the trachea and the sternomastoid muscle is diminished on the side ipsolateral to and accentuated on the side contra

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lateral to the shift. If the first two fingers of one hand are then placed upon the medial borders of the sternomastoid muscles and pressed gently down, the deviation becomes even more striking

Shift of the trachea indicates either an increase or a decrease of volume in a hemothorax and, since foreign bodies are usually accompanied by either atelectasis or obstructive emphysema the importance of this sign is clear

presence of foreign bodies in the air and food passages and radiopaque objects of course are easily demonstrated

A thorough knowledge of the anatomy of the neck and chest and the application of certain principles to the interpretation of x ray films will permit the diagnosis and localization of practically all foreign bodies whether radiopaque or not. Multiple views and fluoroscopy are generally necessary



FIG 2. Posteroanterior and lateral views of the chest and neck of a four year old child showing a penny in the esophagus above the cricopharyngeus muscle. Note position of foreign body in lateral plane Inability to swallow swelling of soft tissues and displacement of the trachea signalize the necessity for emergency treatment.

Shift of the trachea is a dependable sign When demonstrated, its importance should not be discounted, even if the stethacoustic findings are equivocal

Other signs which may aid in the diagnosis and may be present in varying degrees of intensity are cough pain dyspnea, dysphagia wheeze fever sweats and chills

X RAY EXAMINATION X rays are the most useful means of diagnosing the

The following dicta will be found to have great practical value

1 Foreign bodies in the esophagus are arrested at the following levels

Level	*Frequency*
Cricopharyngeus muscle	90%
Cardia	8%
Aortic constricture	2%

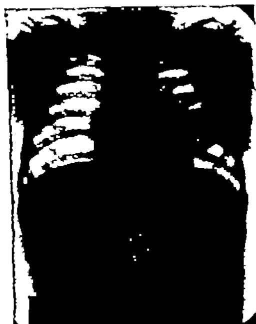
2. Flat foreign bodies are directed into the lateral plane of the body as they enter the upper end of the esophagus and into the sagittal plane as they pass between the vocal cords (Fig. 2)

3 Obstructive phenomena and atelectasis in the lungs are more likely than pneumonia to conform to an anatomical pattern (segmental, lobar pulmonary)

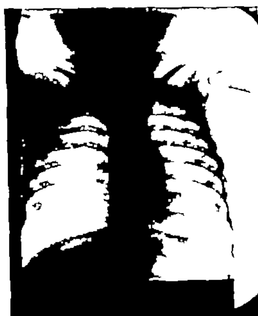
4 In atelectasis, the shadow is constant throughout both phases of respiration. In obstructive emphysema, the normal lung is aerated during inspiration and collapsed during expiration (Fig 3)

Management of Foreign Bodies

Swaddling: Children must be adequately immobilized for foreign body removals This must be accomplished in such a way as absolutely to inhibit the freedom of the extremities without re



A.



B

Fig. 3 Anteroposterior views of the chest in inspiration (A) and expiration (B) showing obstructive emphysema (RT)

5 Air in the esophagus above or below a nonopaque foreign body may be the only x-ray indication of its presence.

6. Straightening of the anterior curve of the cervical vertebrae and widening of the retropharyngeal space is suspicious of and air in the retropharyngeal space is diagnostic of perforation, with or without instrumentation (Fig. 4)

7 Nonopaque foreign bodies in the esophagus may be brought into relief by asking the patient to swallow a pledget of cotton teased out in a contrast medium (Fig. 5)

8. The x-ray examination, particularly in children, should extend from the nose to the pelvis. In cases of multiple foreign bodies, another film should show their absence before discharge In addition to the completion of the clinical record, the last film is a precaution against the possibility of malpractice suits.

stricting respiration. It can be done in the following manner: A mummifying sheet (the size used in a child's crib is usually suitable) is laid across an operating table with a margin of approximately 30 cm (1 foot) at one end, while the other end hangs free. The patient is placed with the body above this sheet and the arms below it (Fig. 6) The free ends are brought around the back from opposite directions The long end is used up in a cone-shaped envelopment of the legs and feet. It is finally fixed in position at top and bottom by safety pins

No one should do foreign-body work in children until he is familiar with this method of mummification

Anesthesia in Children As pointed out above many foreign-body problems involve the risk of death. It is therefore important not to introduce any other risks than those inherent in the problem at hand General anesthesia is such an added risk and, hence should not be used. Local anesthesia in children under ten years of age may also be avoided by the proper technic

It is always best, when circumstances permit, to have the patient carefully and properly prepared The following method has been found satisfactory

A solution of morphine sulfate is made up containing 60 mg. (1 grain) of the drug to 4 cc. (60 minims) of water An initial subcutaneous injection is given consisting of atropine sulfate 0 12 mg (1/500 grain) 0 06 cc (1 minim) of the morphine solution for each 4 5 kg (10 pounds) of body weight. This is followed at intervals of twenty minutes by one half the initial dose of morphine (without atropine)



Fig 4 Lateral view of the neck of a man giving two weeks history of constriction of the neck and "tightness of the collar and four days history of dysphagia. The classical signs of esophageal perforation and retropharyngeal abscess are present. The foreign body (probably a fragment of steel wool) may be seen in the esophageal wall. Prompt drainage (anterior) prevented more serious infection of the lower mediastinum.



Fig. 5 Lateral view of the neck showing barium impregnated cotton pledget in the esophagus impaled upon a splinter of toothpick which was not visible in the conventional exposure.

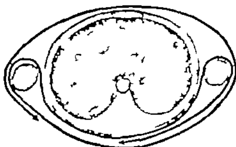


Fig. 6. Cross-section of the chest and arms showing disposition of enveloping sheet.

until the child begins to go to sleep when not disturbed, but can still be aroused The arrival of this stage will be signalized by itching of the nose and perioral blanching.

The bronchoscope can then be passed by taking advantage of the fact that the respiratory mucosa is very tolerant to a foreign body at rest, although it is very intolerant to a foreign body in motion The child is placed on the operating table with the lights turned off in complete quiet. He will gradually go to sleep As soon as respirations begin to become slower and shallower the instrument may be slipped easily into the trachea. The patient will protest. The bronchoscope is immediately brought to rest until the patient goes to sleep again. The instrument is advanced with alternate movement and rest until the foreign body is exposed and good visualization obtained.

Complete immobility is then maintained for a slightly longer period, which permits the child to enter into a deeper sleep The foreign body may then be grasped securely and withdrawn, using *the same technic of alternating rest and* movement on the way out.

Following removal of the foreign body the patient should be left under the continual supervision of a special nurse or a responsible relative who is charged with the duty of preventing the infant from sleeping too deeply until the effect of the morphine wears off—a period usually of about two hours.

Anesthesia in Adults. Of the several local anesthetic agents which are available for use cocaine hydrochloride is the most effective. It is, also perhaps the most toxic. However if the following "progressive dilution" method of using this drug is strictly observed, all toxic reactions may be eliminated.

The maximum amount of anesthetic to be used for an adult is limited to 2 cc of ten per cent solution, or its equivalent. The area of surface application is also limited to the larynx and trachea. As a consequence sprays, nebulizers applicators and sponges are not used. By means of a laryngeal syringe a few drops of cocaine are directed onto the vocal cords If visualization is easy the ten per cent solution may be used, if not, it should be diluted to five per cent. After each use of the reagent, the syringe is refilled to the starting point with distilled water A delay of approximately two seconds in cough indicates that the bifurcation has been reached and controlled. The lower part of the bronchi may be anesthetized by washing the solution down from above with plain distilled water

The same preparation is used for esophagoscopy The gag reflex and closure of the cricopharyngeus muscle are products of the subconscious mind and, hence cannot be reached by any form of anesthesia except deep third stage general. Spasm of this muscle derives *from the fear of foreign body invasion* of the respiratory not the digestive tract. Hence elimination of cough is the best method of obtaining relaxation. Local anesthesia is the best method of eliminating cough.

Instrumentarium Generally speaking, the American-made distally illuminated instruments are superior to the proximally illuminated ones of European origin

Personal preference must determine the individual design selected and the choice of equipment for a particular problem. It is a good rule however to prepare in advance for every possible contingency and to treat every case as though complications and difficulties

were anticipated. In this way complications and difficulties will be avoided

No surgeon should undertake foreign body work without at least a "minimum working set" of instruments Usually additional forceps are required for special problems

In my work I have found the 17 cm anterior commissure laryngoscope (Jackson) and the 20 cm tracheoscope (Jackson) the most useful specula for the larynx pyriform fossae and upper esophagus depending upon the position of the foreign body and the age of the patient. This is a minor deviation from most texts

A warning should also be given in respect to the size of bronchoscope to be used Many times an instrument larger than the indicated caliber is chosen in order to obtain a wider field and better visualization In fact, the extra millimeter of diameter in a tube 30 to 40 cm long offers little advantage to the experienced endoscopist, but may be enough to induce subglottic edema and precipitate an emergency postoperative tracheotomy This is particularly true in children

Technic of Removal Every foreign-body case is an individual problem particularly with respect to the mechanical difficulties which may be presented It is safe to say however that any foreign object can be taken out through the same passage which admitted it. The performance of tracheotomies to circumvent the larynx is unnecessary and to be deplored On the other hand, laryngeal obstruction in the absence of adequate facilities for immediate use is a clear indication for tracheotomy which should be done without hesitation

Quite frequently foreign bodies in the upper esophagus are released by the approaching esophagoscope and may descend to the stomach Unless flexible forceps (Tucker) or a flexible electromagnet (Penta) are available for use under biplane fluoroscopic control these cases do not require emergency treatment. The administration of bulky foods to "envelop" the foreign body is useless and of drugs to increase peristalsis, is dangerous Such patients should be kept under observation, on a regular diet, and fluoroscoped daily The location of the foreign body should be marked on the skin in indelible ink If it fails to change position in forty-eight hours a surgeon should be consulted Operation is indicated if symptoms signify local irritation or obstruction. It is remarkable, however what large objects will pass without delay through the digestive tract of even small children. Not more than one in a thousand will require intervention.

MEDIASTINITIS

At birth, there are no fascial planes in the neck The groundwork is present in the form of loosely connected reticuloendothelial cells Time and function build these cells into five planes. The neck, however is not completely compartmentalized and there is always the possibility of communication from one plane to another—particularly in the first four planes The carotid sheath may also communicate freely with the pericardium It is important to remember these features in case of esophageal perforation or periesophagitis

The fascial planes of the neck may be outlined as follows

First plane: Subcutaneous fascia and platysma muscle.

Second plane Sternomastoid and trapezius muscle fascia. *Third plane* Sternohyoid muscle fascia.	These planes blend posteriorly

Fourth plane Sternothyroid and carotid sheath fascia (blends with pretracheal fascia and capsule of thyroid gland)

Fifth plane Prevertebral, or retrovisceral fascia.

The fifth plane is the barrier which principally concerns the surgeon who has to deal with foreign bodies because it forms the anterior limiting wall of the posterior mediastinal space This space extends from the base of the skull to the diaphragm and gives access to the entire retrocardiac and retropleural area which is occupied only by fat and loosely knit areolar tissue The space may be invaded transesophageally with or without perforation. It may be invaded through an obscure perforation by a foreign body which is nonradiopaque, which is hidden by other structures—particularly the heart and the pectoral girdle—or which cannot be brought into view by esophagoscopy due to swelling and ulceration. Such foreign bodies are small fragments of glass fish bones, and segments of steel wool and metal filings which are used for cleaning pots and pans Usually there is the history of a foreign-body episode, but this may not be obtainable. The patient complains of a sense of fullness or constriction in the neck, tightness of the collar pain, and dysphagia Physical examination may reveal a nasal intonation on phonation. There is a fullness and bogginess on pressure between the trachea and the sternomastoid muscles Tenderness is elicited by deep pressure in the suprasternal notch. Crepitus may be present anywhere along the anterior border of the sternomastoid muscle. The posterior pharyngeal wall is displaced anteriorly may be visibly bulging and may impinge upon the posterior nares

A lateral view of the neck shows straightening of the anterior curvature of the cervical spine and widening of the retropharyngeal space Air may be present and, if so the pharyngeal wall is usually separated from its attachments up to the base of the skull A foreign body may or may not be shown, depending upon (a) whether or not one is still present at the site (b) whether or not it is radiopaque and (c) whether or not it is obscured by other structures In any event, such a case represents a real surgical emergency and requires immediate treatment.

Generally speaking it is proper to inspect the upper end of the esophagus in the hope that the foreign body may be seen and removed. Usually this will not be possible due to swelling, cyanosis and ulceration. Instrumentation is dangerous and should be carried out with the greatest caution and restraint. It is better to leave the foreign body *in situ* than to produce a perforation of the esophagus or to increase one which may already be present. The posterior wall of the esophagus just above the musculus cricopharyngeus is deficient in muscle and is not more than 2 to 3 mm. in thickness In the presence of edema or ulceration, a perforation may be caused by the gentlest manipulation and even without the knowledge of the operator

In the opinion of the writer every surgeon who does foreign-body work should be able to perform a mediastinotomy (anterior approach) Many hospitals in which foreign-body cases must be handled have no thoracic surgeon on the staff, and, occasionally time lost in seeking or waiting for a thoracic surgeon may spell the difference between life and death, or at least, between the simple anterior and the more difficult and dangerous posterior drainage

Mediastinitis due to perforation of the esophagus was, until recent years, a uniformly fatal condition From this fact was derived the belief that mediastinitis was a dangerous disease This opinion persisted for many years in spite of the *knowledge that other wounds involving* the mediastinum required no special attention. The real cause of death in this particular type of mediastinal infection is the pressure produced within the esophagus by the act of swallowing. The mediastinum fails to wall off or localize an invader simply because it never has time and not because it is unable (anatomically speaking) to do so

For this reason I do not agree with those who advocate the administration of antibiotics as a trial method of therapy

The entire subject of mediastinitis will receive full treatment in another section of this book My remarks will be confined to two operative procedures in the neck which will prevent a great deal of trouble if done at the proper time and in the proper way

Mention has been made above of the loose areolar nature of the mediastinal content the pressure of swallowing, and the usual absence of localization. It would appear therefore that the surgical creation of an escape vent for the content of the mouth (air and saliva) would prevent the spread of infection in the mediastinum This can be done in two ways as follows

(1) Posterior pharyngotomy

(2) Posterior mediastinotomy (anterior approach)

The cricopharyngeus muscle, in addition to the circular fibers which are its principal component, has a variable attachment at the sides to the anterior vertebral ligament. It is therefore capable of effecting closure of the esophagus by two actions (a) A purse-string like constriction and (b) a backward compression of the esophagus against the vertebral column. In cases where this latter action is strong, it temporarily inhibits progression downward into the *posterior mediastinum of infections from* above and may be the principal factor in determining the kind of surgical approach to be used If there is localization above the muscle (retropharyngeal abscess) and the chest x rays show a normal mediastinal shadow a posterior pharyngotomy is the procedure of choice.

Posterior Pharyngotomy The patient is placed upon the operating table in Trendelenburg position—the head pointing downward at about forty five degrees Suction is readied to evacuate the mouth as soon as drainage is started, so as to prevent aspiration of pus into the lungs A 17 cm laryngoscope is used to select the point above the posterior commissure of maximum fluctuation An incision is made with a long, curved tonsil knife through the posterior pharyngeal wall There is less bleeding if a *midline site* is chosen After the abscess is empty and the field can again be seen, the opening may be enlarged by use of long, thin forceps (uterine packing)

Mediastinotomy (Anterior Approach) If localization is not definite if there is air in the retropharyngeal space, or if the upper mediastinal shadow in the posteroanterior chest x rays is widened or has a fuzzy outline then it is necessary to attempt to get ahead of the infection by an approach through the neck. The patient is placed upon the table in the thyroidectomy position. The side of the neck is chosen where swelling and tenderness are greatest, or where crepitus can be felt. An incision is made

along the anterior border of the sternomastoid muscle from the suprasternal notch upward to a point about 1 cm beyond the external jugular vein. The vein need not be severed. By sharp and blunt dissection the fascial planes are divided and the carotid sheath is separated from the trachea and thyroid The inferior thyroid artery and vein are isolated and cut between ligatures If the trachea is then rotated toward the opposite side, the esophagus comes into view It is picked up by a nontraumatic clamp (Babcock) and a space is created between its posterior wall and the vertebral column. This can best be done by the finger or by the use of a curved clamp tipped by a pledget of gauze For the success of this operation it is not necessary to discover pus or even air In fact, if pus is revealed, it is probably already too late and a mediastinotomy using a posterior approach, should be resorted to without delay A Penrose tube drain is placed in position and the wound is closed The superficial fascia, including the platysma and the skin, should be approximated by interrupted sutures of suitable material. The drain may be removed on the second to the fifth day depending on the amount of drainage.

By entering the posterior mediastinum lateral to the carotid sheath, the inferior thyroid artery and vein may be saved This method, however lays bare the internal jugular vein which may be eroded by drains instruments or slough.

14

Nonpenetrating Thoracic Injuries

Introduction In this mechanical and war torn world in which we live traumatic injuries of all kinds are an increasing problem to be met and intelligently treated. Thoracic injuries represent a considerable portion of such injuries They should always be considered as serious because they so frequently result in alterations in the vital cardiorespiratory mechanisms When severe they represent an immediate threat to the patient s life In such cases, prompt treatment aimed at returning the cardiorespiratory physiology to normal can be lifesaving

Thoracic injuries are classified as *penetrating* and *nonpenetrating* This chapter will deal only with the non penetrating types These are usually the result of concussion or compression of the chest by direct blows steering wheel injuries falls and crushing by opposing forces. Theoretically a tangential wound which does not traverse the pleura is a nonpenetrating wound but this is of little importance and will not be included in the following discussion

Injuries may vary in severity from a simple contusion of the chest wall to an immediately fatal injury involving one or more of the vital intrathoracic organs such as rupture of the ventricle auricle great vessels, or lungs It cannot be emphasized too forcibly that external evidence of injury is in no way a measure of the severity of the internal injuries sustained by such accidents Not infrequently ribs are fractured without evidence of trauma to the superficial tissues Likewise the thoracic cage may be damaged without injury to the intrathoracic structures. However it is most important to realize that fatal injury of the intrathoracic viscera may occur without fracture of the ribs or evidence of severe trauma to the tissues of the chest wall This is especially true in the resilient chests of younger individuals. Nevertheless, severe injuries usually involve both the thoracic cage and intrathoracic structures

The clinical evaluation and approach to treatment of the patient with a serious chest injury involves many problems peculiar to thoracic injury especially those concerned with the pathological physiology These will be discussed under appropriate headings

RIB FRACTURES

Rib fractures are very common following trauma to the chest. Single or localized rib fractures are usually the result of a direct blow Multiple rib fractures are frequently the result of severe direct trauma or a compression type of injury which virtually snaps the ribs, not infrequently bilaterally Fol-

lowing direct blows the rib fragments may be depressed and cause injury to the vessels of the chest wall or the lung Following compression the rib fragments are usually driven outward and rarely cause injury to the underlying structures If the lung or vessels are injured in such cases the injury is due to the same violence which caused the rib fractures The "steering wheel" accident is the classical example of this

Single rib fracture frequently requires no therapy except partial immobilization by adhesive strapping of the chest. The adhesive should be applied during expiration and should extend a few centimeters (inches) beyond the midline both anteriorly and posteriorly The costal margins should always be immobilized as well as the local area of the fracture

The depressed rib fracture not associated with injury to underlying structures can usually be treated as a simple rib fracture However if the splintered rib fragments have already caused injury to the lung and are in position to create further damage to the expanding lung the splintered portion of the rib should be removed and the rib ends fixed by wiring the two segments together This can usually be done under local anesthesia.

With multiple rib fractures the treatment includes the control of pain, control of paradoxical motion, and the prevention of the "wet lung" syndrome Intercostal nerve block is usually desirable in such cases. This reduces pain, reduces muscle spasm, and facilitates cough and expectoration of secretions As a rule, this will prevent the development of "wet lung" due to retained secretions. Frequently additional measures will be required to control the paradoxical motion. Adhesive strapping of the costal margin careful padding over the fracture sites and the use of sandbags may be indicated. If multiple rib fractures are complicated by serious injury to the lung with uncontrolled pneumothorax or intrapleural hemorrhage open thoracotomy may be the wisest approach. During this procedure the rib fragments can be fixed and the injured lung treated as indicated

At times several adjacent ribs are fractured in two or more places causing a paradoxically moving section of the chest wall. (Stove in Chest, see Fig 1) This is always a serious injury and requires immediate treatment. The excessive paradoxical motion must be stopped and the bronchial tree kept free of secretions *These are the keystones of successful treatment and are lifesaving* To control the paradoxical motion, padding over the "stove in" area with adhesive strapping support may be effective Not infrequently this is insufficient. If so the "stove in" ribs must be fixed by towel clips or wire traction or by direct operative fixation. At the first sign of retained bronchial secretions tracheal aspiration with a catheter or bronchoscopy should be performed. If secretions reaccumulate rapidly or if the patient is cyanotic, there should be no hesitation to perform a tracheotomy This facilitates the frequent aspiration of secretions, reduces dead space air reduces resistence to expiration, and also permits oxygen to be administered directly into the tracheobronchial tree These measures should not be reserved for treatment when the patient has become critically ill. They should be used at the earliest time at which it becomes evident that other measures are failing to control the paradoxical motion and the accumulation of bronchial secretions.

At times, the "stove in" area of the

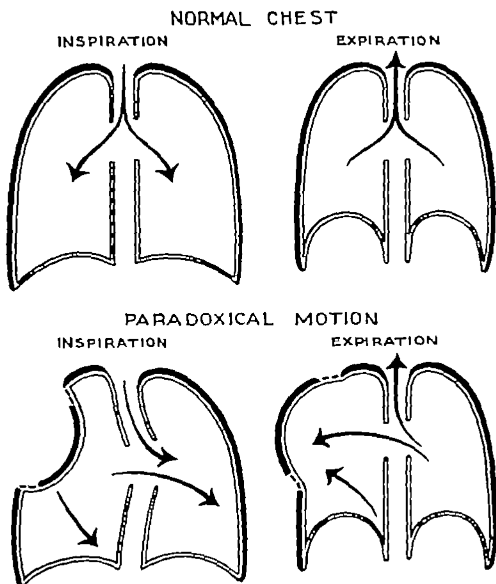


FIG. 1 These diagrams illustrate the mechanics of inspiration and expiration in the normal chest in contrast to one with a paradoxically moving section of the chest wall created by multiple fractured ribs on the "stove in" chest.

In the normal chest, the thoracic cage and diaphragms move synchronously and equally on both sides. As a result, an equal draft of air enters each lung during inspiration and is forced out during expiration. There is no crossing of currents of air at the carina.

The paradoxically moving section of the chest wall is sucked inward during inspiration at a time when all other areas of the chest wall are expanding. Just the reverse occurs during expiration. This mechanism causes both air and secretions to swish back and forth as indicated by the arrows in the illustration. Mediastinal flutter also results. The end results of paradoxical motion are anoxemia due to insufficient ventilation pneumonitis due to retained secretions, and potential heart failure due to interference with return of blood to the right heart.

tend to suck more air from the lung. Groaning, straining coughing and sneezing will increase intrapulmonary pressure and push more air into the pleural cavity These mechanisms cause increasing positive pressure in the pneu mothorax space As the tension mounts, the pleura is stretched causing pain. The lung is compressed the diaphragm depressed and limited in its motion, and the mediastinum displaced with resulting compression and reduced function of the contralateral lung Dyspnea and cya nosis are the result. In addition, circula tory embarrassment is superimposed be cause of torsion of the mediastinal vessels and the pressure on the auricle and veins which interfere with diastolic filling of the heart. This combination of disturbed respiratory and circulatory physiology constitutes the real emer gency of tension pneumothorax and must be corrected immediately Other wise the patient will die of suffocation and cardiac failure.

The diagnosis of tension pneumothorax should be suspected in any patient who has sustained an injury and is dyspneic with or without cyanosis It can easily be confirmed by physical exami nation. There will be signs of pneumothorax over the affected side the trachea and apex beat of the heart will be dis placed toward the opposite side and retrosternal dullness will be replaced by a hyperresonant note Further confirma tion by roentgenological examination is possible if the patient's condition per mits. At times, however the patient's condition is so critical when first seen that there is no time for such procedures

The emergency treatment of tension pneumothorax is the introduction of an #18 gauge or larger needle into the pneumothorax space and withdrawing sufficient air to relieve the tension and the associated symptoms This may be done with or without local infiltration with procaine If thoracentesis equipment is not available for aspiration, the needle can be inserted into the pleural space and air allowed to escape Aspi ration of air must be repeated as often as necessary to prevent recurrence of tension pneumothorax and dyspnea. As soon as equipment can be made ready a catheter should be introduced through a trocar into the pleural space and connected to a water-seal drainage bottle (Fig. 2) If air is escaping rapidly from the lung it may be necessary to connect the catheter to a negative pressure system (Fig 2) These procedures will prevent recurrence of tension in the pleural space and obviate the necessity of constant observation and repeated thoracenteses. In addition they en courage rapid reexpansion of the lung and early obliteration of the pleural cavity—goals to be striven for in treat ing any pleural complication. Should there be any significant amount of intrapleural bleeding, blood loss through the catheter may assume dangerous levels and must be watched for Frequent observation and measurement of the blood escaping through the drain age system should be made to guard against excessive blood loss. Constant catheter drainage is contraindicated by continuous or significant intrapleural hemorrhage. Under such circumstances repeated thoracentesis should be relied upon to control the pleural pressures and just sufficient air blood, or both removed to relieve symptoms If this fails to control the situation open thoracotomy is indicated at which time the bleeding can be controlled and the damaged lung repaired

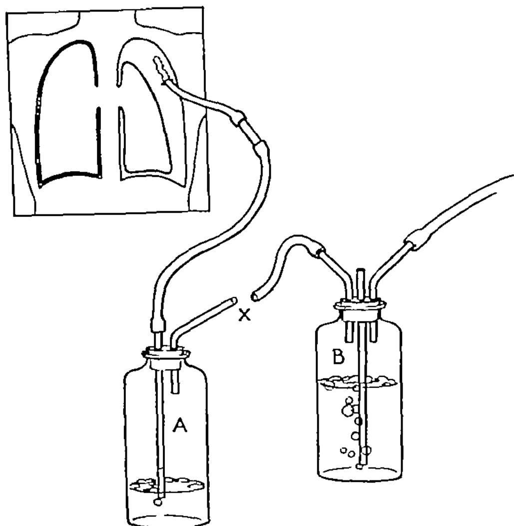


FIG 2. This diagram illustrates both the water-seal and negative pressure drainage systems. If only bottle A is connected to the chest catheter air will escape through the tube when the intrapleural pressure exceeds the depth of the tube beneath the water. This system is in reality a positive pressure trap since a slight positive pressure is necessary to cause air to escape. The depth of the tube beneath the water regulates this pressure.

When both bottles are connected, a negative pressure trap is established. The tube beneath the water and open to the air in bottle B regulates this negative pressure. This system creates constant suction on the pleural cavity. The open tube in bottle B is usually kept 8 to 12 cm. below the water level thus creating corresponding suction in the pleural cavity.

CONTROL OF HEMORRHAGE AND MANAGEMENT OF HEMOTHORAX

Bleeding into the pleural cavity should always be suspected and looked for following any thoracic injury. Intrapleural bleeding of some degree is usually found if the trauma has been severe. It usually is manifest immediately following the injury. However *delayed bleeding* may occur, the collection of blood in the pleural cavity becoming manifest only after several hours or even a few days.

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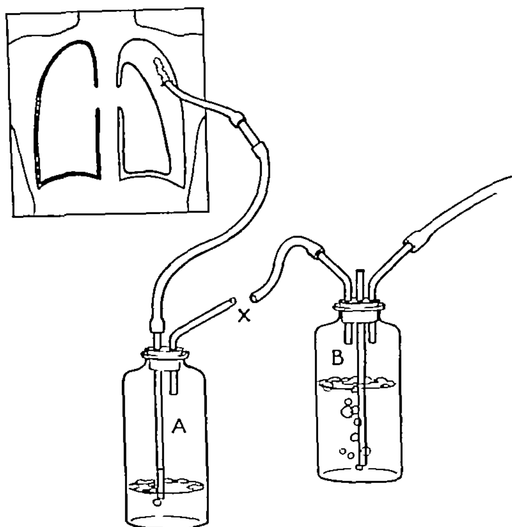


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thorax are the intercostal and internal mammary vessels and the lung Damage to these structures results either from compression injury or a depressed rib fracture Less frequently disruption of one of the major intrathoracic vessels occurs When the lung is injured, both air and blood escape into the pleural cavity and then the physician is confronted not only with the problems of blood loss and hemothorax but also with an existing or potential tension pneumothorax.

The immediate threats of hemothorax are excessive blood loss and the disturbance of both respiration and circulation as a result of collapse of the lung in addition to pressure on and displacement of the mediastinal structures The physician must always be conscious of the fact that a patient can bleed to death into his pleural cavity Likewise, bleeding insufficient in itself to cause death, may turn the tide in a severely injured patient who otherwise might recover Disturbances of the cardiorespiratory mechanism are particularly serious in those patients, especially the elderly ones who have impaired physiological reserves prior to the accident.

When the bleeding originates in any of the major intrathoracic vessels bleeding is usually profuse rapidly fatal and, as a result, rarely seen as a therapeutic problem Bleeding from the intercostal and internal mammary arteries is apt to be brisk and cause signs of continued blood loss and reaccumulation of blood in the pleural cavity As a result, open thoracotomy is frequently necessary to control the hemorrhage Blood loss from an injured pulmonary vessel is a slower process because of the low pressures in these vessels and also because the accumulated blood and air in the pleural cavity has a tamponading effect on the bleeding points in the compressible lung parenchyma At times serious bleeding may occur secondary to injury of one of the larger branches of the pulmonary vessels near the hilum Hemoptysis is usually associated with lacerations of the lung

Treatment When signs of fluid occur in the chest immediately or shortly after an injury a diagnosis of hemothorax can be made with confidence since intrapleural bleeding is the only mechanism that can produce pleural fluid so quickly If the patient is in shock, the physician s task is to determine whether it is due to the chest injury and intrapleural bleeding or to injuries elsewhere Once it has been decided that intrapleural hemorrhage is the major factor the immediate treatment consists of combating shock, controlling hemorrhage and correcting any disturbance of the cardiopulmonary physiology Morphine, blood transfusions and oxygen are indicated for the shock. If the patient has severe pain due to fractured ribs an intercostal nerve block with novocain will reduce pain and paradoxical motion and thus make both coughing and breathing more effective Sufficient blood, air or both should be removed from the pleural cavity to relieve excessive compression of the lung or displacement of the mediastinum. However it is important to emphasize that only sufficient blood should be removed to correct the disturbed physiology At no time should an attempt be made early especially in the severely injured patient, to remove more than this amount since it may cause recurrence or increase of bleeding

The patient is observed carefully with frequent checks on his general condition pulse blood pressure and posi

tion of the mediastinum If signs of bleeding persist or recur open thoracotomy is indicated to control the hemorrhage which under such circumstances usually originates from an artery (intercostal or internal mammary) or from one of the larger pulmonary vessels near the hilum. Bleeding from any of the chest wall vessels can be controlled by simple ligation Bleeding from a large pulmonary vessel or from a severely lacerated lung frequently can be controlled by ligation and suture but may require resection of the damaged portion of the lung

In a large percentage of cases, intrapleural hemorrhage originates from a lacerated lung or from an intercostal or internal mammary vein. Here the tendency is for spontaneous cessation of bleeding, the increasing tension in the pleural cavity causing compression on these vessels with relatively low pressures It is self-evident why it is contraindicated to reduce the intrapleural pressures too much in such cases during the first forty-eight hours when only sufficient fluid should be removed to correct excessive mediastinal displacement, dyspnea, and cyanosis After forty-eight hours, however the blood should be removed completely within the space of a few days. At this time, the aim of treatment is to reexpand the lung and obliterate the pleural cavity to prevent the deposition of fibrin and the development of fibrothorax. Fibrothorax, with or without a nonexpandable lung, results in a high percentage of cases if blood is permitted to remain too long in the pleural cavity This results in marked reduction of pulmonary ventilation and may require subsequent decortication if it is permitted to develop Adequate respiratory exercises after the blood has been aspirated are also indicated to help the patient regain costal and diaphragmatic motion and reduce pleural thickening

The late complications of hemothorax are fibrothorax nonexpandable lung and empyema These can all be prevented in the majority of cases by the use of adequate antibiotics and rapid obliteration of the pleural space Should empyema develop in a large space it is best treated by thoracotomy and decortication If only a small residual empyema space results it may be handled by simple open drainage Fibrothorax and nonexpandable lung are indications for decortication

As a rule, blood in the pleural cavity does not clot and can be removed easily Should it tend to clot, or should excessive fibrin be deposited, the use of one of the proteolytic enzymes (streptokinase and streptodornase or tryptar) may be found useful in liquefying the clots and thus permitting aspiration of the fluid.

INJURY TO THE LUNG AND AIRWAYS

Nonpenetrating injuries of the thorax when severe are usually associated with either contusion or disruption of the underlying lung. Disruption will result in pneumothorax, hemothorax, or both Contusion results in extravasation of blood into the pulmonary tissue at times with hematoma formation. Severe contusion is so common and so frequently is the forerunner of infection that prophylactic chemotherapy should be administered to all patients who have suffered a serious chest injury It is important—in fact it is vital—*that the physician realizes that not infrequently a "contre-coup" injury results in which* case the lung opposite to the injured side is involved Under such conditions

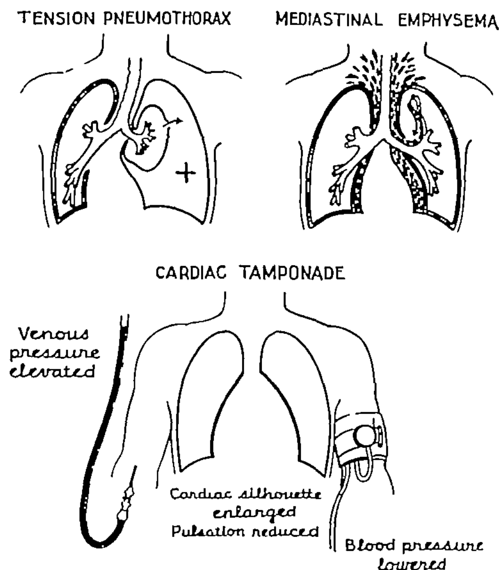


FIG. 3 These diagrams illustrate three of the common emergencies resulting from thoracic trauma

Tension Pneumothorax: The air escapes from the lung into the pleural cavity through a pleuropulmonary tear The intrapleural pressures are positive The lung is collapsed. The diaphragm is depressed. The mediastinum is displaced toward the opposite side causing compression of the contralateral lung.

Blood or fluid in the pleural cavity may cause exactly the same mechanical and physiological disturbances.

Mediastinal Emphysema: Air escapes from a ruptured alveolus and dissects along the perivascular and peribronchial areolar tissue out through the hilum into the mediastinum This illustration shows the air escaping from the mediastinum into the tissue of the neck resulting in subcutaneous emphysema.

Cardiac Tamponade The three cardinal signs of cardiac tamponade are illustrated—(1) the large heart with reduced pulsations, (2) elevated venous pressure and (3) lowered blood pressure.

adequate treatment as indicated for both sides is necessary It also should be re-emphasized that external evidence of trauma is in no way a measure of the degree of damage to the lungs or any other intrathoracic structure.

A rare type of complication is dis ruption of the trachea or a major bronchus. This requires operative re pair as soon as the patient s condition permits

MEDIASTINAL EMPHYSEMA

Mediastinal emphysema usually re sults from air escaping from ruptured alveoli and dissecting in the areolar tissue around the bronchovascular struc tures out through the hilum into the mediastinum (Fig. 3) It may be caused also by air escaping from a ruptured esophagus trachea or primary bronchus This complication probably oc curs more frequently than we suspect because the diagnosis is often missed. When present, a crunching, crackling sound synchronous with the heart beat can be heard over the mediastinum and the roentgenogram reveals an area of radiolucency along the pericardium and upper mediastinal shadow When air in the mediastinum escapes readily into the subcutaneous tissue it is rarely serious. Therefore the development of subcu taneous emphysema in the neck is re assuring and is not a danger sign Mediastinal emphysema becomes dangerous when air continues to enter the mediastinum but cannot find a ready exit. Then tension increases in the mediasti num causing pressure on veins and interfering with filling of the right heart. In addition bilateral pneumothorax is a fairly common complication due to rupture of the mediastinal pleurae When air becomes locked in the mediastinum under such high pressure it must be relieved This is accomplished through a small incision in the supra sternal region and opening into the mediastinum to permit its escape

SUBCUTANEOUS EMPHYSEMA

This is not a serious complication al though it may be distressing to the pa tient. The diagnosis is easily made by palpating the crepitation in the subcu taneous tissue Except when it is found in association with mediastinal emphys ema it results from air escaping di rectly from an adherent lung or from a pneumothorax space. This is most commonly caused by injury to the lung by a depressed rib fracture No treat ment is required except the control of the causative factor The air is slowly absorbed.

BLAST INJURY

Blast injury is rarely seen in civilian life but is commonly seen during war as a result of bombing and depth charges Following an explosion there is a marked increase in air pressure (compression wave) followed immedi ately by a negative wave (suction wave) The blast injury is due largely to the compression wave. It results from compression of the chest and not direct action on the lung itself The fundamental pathology in the lung is multiple hemorrhages into the alveolar and interstitial tissues In addition mediastinal emphysema, pneumothorax, hemorrhage liver damage cerebral injury or even rupture of a major vessel may be found

The initial shock is apt to be severe However a latent period may occur with the patient developing severe respiratory symptoms and collapse after many hours have passed. Cough bloody sputum, dyspnea, and cyanosis are com-

mon symptoms Roentgenograms reveal areas of density due to confluent hemorrhages

Treatment is conservative and consists of bed rest, relief of pain and oxygen Prophylactic penicillin should be given to prevent pneumonia. All activity and motion by the patient is forbidden to guard against continued bleeding into the lung Intravenous fluids must be given with caution because pulmonary edema develops so readily These patients are extremely poor surgical risks and ultraconservatism should be exercised in approaching any associated condition which otherwise would be treated surgically

TRAUMATIC HEART DISEASE FOLLOWING NONPENETRATING THORACIC INJURIES

Injury to the heart and pericardium associated with nonpenetrating thoracic injuries is commoner than one would suspect. Although many cardiac symptoms and abnormalities are attributed falsely to trauma it is undoubtedly true that failure to diagnose traumatic heart disease is commoner than is mistaken diagnosis

Etiology The commonest cause of nonpenetrating cardiac injury is a forceful blow over the precordium. This may be caused by any object travelling at high speed such as a golf ball baseball, or fist However striking the chest against the steering wheel or back seat of an automobile is probably the commonest cause In addition, anterior posterior compression of the chest resulting in displacement of the heart or compression of the heart between sternum and spine is fairly common A car running over the chest, and crushing by machinery belts are examples of this type of injury Cardiac injury may also result from direct injury by a depressed rib or sternal fracture or secondary to blast injury

Types of Injury· Injury to the heart following nonpenetrating wounds varies widely in severity and seriousness. When the compressing force is especially severe the heart may be torn completely from its attachments to the great vessels and lie free in the thorax or more than one chamber of the heart may rupture Needless to say such cases do not fall into the therapeutic realm death occurring immediately Contusion to the pericardium or subpericardial hemorrhages are common and may result in pericardial effusion. Contusion to the myocardium with fragmentation of the muscle fibers is also common. This may result in pericardial effusion, delayed rupture aneurysm formation, arrhythmia and electrocardiographic changes similar to myocardial infarction resulting from coronary occlusion. The valves may be torn resulting in valvular insufficiency and the development of murmurs Injury to the endocardium may result in intracardiac thrombosis which may be the source of subsequent peripheral or pulmonary emboli

Diagnosis Cardiac contusion must be suspected in any patient who has sustained a chest injury especially a crushing injury with bilaterally fractured ribs, or a forceful blow over the precordium Here again we must emphasize that serious injury to the heart is frequently sustained when there is little or no evidence of external trauma The diagnosis is based on the following

1 The development of a pericardial friction rub
2 The development of a pericardial effusion.
3 The development of murmurs or thrills.
4 The development of signs of heart failure
5 Electrocardiographic evidence of cardiac anoxia or infarction.

Treatment The emergency treatment of cardiac damage associated with chest injuries centers around the recognition and prompt relief of cardiac tamponade (Fig. 3) The classical signs of tamponade are (1) Lowered arterial pressure (2) increased venous pressure and (3) enlarged pericardial shadow and reduced pulsation by fluoroscopic examination The increased intrapericardial pressure interferes with venous return to the heart and unless relieved, will result in cardiac failure shock, and death.

Tamponade developing shortly after the accident is usually due to the accumulation of blood in the pericardium as a result of rupture of the heart. A needle should be inserted into the pericardium by way of the subzyphoid route and sufficient blood removed to relieve the signs of tamponade The operating room is set up immediately If signs of tamponade recur pericardiocentesis should be repeated in order to improve the patient s condition and then operation performed. The pericardium is opened, the blood removed, the cardiac rupture sutured and, if necessary reinforced with a pericardial graft

Pericardial effusions occurring late are usually serous and can, as a rule be handled merely by pericardial taps Delayed rupture may be the cause of delayed tamponade

The only other factors of importance in the early treatment of these cases is that the clinician should be conscious of the added burden and potential danger cardiac injury represents in the severely injured patient Oxygen should be given for several days Arrhythmia and signs of cardiac failure should be treated adequately and early The patient should be kept at bed rest for several weeks to minimize delayed rupture of the lacerated or contused myocardium

CONCLUSIONS

The emergency treatment of patients who have sustained a thoracic injury consists of the following

(1) The control of shock.
(2) The control of bleeding.
(3) The correction of altered cardiopulmonary physiology
  (a) Tension pneumothorax.
  (b) Hemothorax.
  (c) Mediastinal emphysema.
  (d) Paradoxical motion.
  (e) Cardiac tamponade.
(4) The prevention of "wet lung syndrome."
  (a) Antibiotics.
  (b) Control of paradoxical motion.
  (c) Tracheal aspiration and bronchoscopy
  (d) Tracheotomy

Evidence of external trauma is a poor indication of the severity of injury to intrathoracic organs However severe trauma usually results in injury to both the structures of the chest wall and intrathoracic structures

"Contre-coup" injuries should always be suspected Not infrequently the contralateral lung suffers serious trauma resulting in pneumothorax or hemothorax.

The patient with a chest injury frequently has other associated injuries of a serious nature Needless to say the subdural hematoma, the ruptured spleen or the fractured femur should be treated intelligently and concomitantly In such cases it is usually necessary to have a team of surgeons experienced in these specialties working together However it is vital that one surgeon supervise the treatment and coordinate the activities of the various members of such a team Proper treatment of such severely injured cases requires diligent observation over many hours and even days The

devotion of a competent physician is probably the most essential factor in the successful treatment of such patients

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REEVE H BETTS M.D

15

Traumatic Lesions of the Thorax
(Exclusive of the Heart)

THE management of trauma of the thorax has improved in efficiency concurrently with the advance in knowledge of thoracic physiology Surgical treatment of many thoracic diseases has stimulated interest in related investigational fields and in many instances has provided visual corroboration of predicted conditions Although all therapeutic methods of treating traumatic injuries were improved as a result of the large experience during World War II, the improvement in treatment of chest trauma was preeminent. Technological developments and the resultant faster modes of travel have tended to increase the number and severity of thoracic traumatic lesions in civilian life No hospital location is so remote but that facilities for the care of thoracic injuries must be at hand. This does not mean necessarily equipment and personnel to do major intrathoracic procedures as it has been amply demonstrated that when such are not available the best results are obtained by intelligent first aid measures and then transferring the patient to a fully equipped center for any definitive management that may be needed. The equipment for first-aid measures can be assembled readily in any hospital.

The criteria of successful management of thoracic traumatic lesions involves in the main three things (1) Means of aspirating or decompressing the pleural cavity of air blood or both In most instances, needle aspiration (preferably with a three way stopcock attachment) is sufficient. Occasionally an intercostal tube may have to be inserted. (2) Maintenance of an airway free of blood or mucus. For this an aspirating catheter to be introduced through a nostril and then into the trachea and bronchi usually suffices. When this is not effective bronchoscopic aspiration is indicated. (3) Media for restoration of the circulating blood volume When there has been major blood loss and the patient is in a state of shock, blood is by far the most satisfactory means of restoring the circulation. If blood is not readily available, plasma, electrolyte solutions or some form of the newer plasma substitutes may be used

With the proper employment of the above measures the objectives of a restored normal cardiorespiratory function the complete expansion of the lung against an intact or restored thoracic cage, and a clear airway can, in most instances, be achieved When the above has been accomplished, the other fac

tor of prevention of infection is usually not difficult. If the pleural space is not evacuated the lung not fully expanded or the airway not free, infection is a much commoner complication

Although the most extensive experience in thoracic traumatic lesions has been in war injuries the principles of treatment of the latter and of civilian injuries are the same and in this discussion they will be considered together Two factors tend to differentiate the two groups In war surgery the patients are for the most part young, healthy adult males with excellent resistance while civilian casualties are a mixed group The facilities however for the care of the patient should be better in the civilian group than for those injured in war time

GENERAL CONSIDERATIONS

Emergency Treatment About the only thoracic injury demanding immediate treatment is the closure of a sucking wound Sucking wounds 5 to 7 5 cm. (2 to 3 inches) in diameter often create greater disturbances than those either smaller or larger Small wounds tend to become occluded by the surrounding muscles while very large wounds produce a complete collapse of the lung and may not be accompanied by as much pendulum breathing from shifting of the mediastinum as is present in a medium sized one In some instances the defect can be occluded by placing the patient s arm or shoulder in a proper position to cause the muscle to overlie the defect. It is usually not necessary to remove the pneumothorax as an emergency measure

Any large voluminous dressing will be effective temporarily in occluding the wound until the patient can be treated in a hospital A layer of petrolatum gauze is helpful as a basic dressing. Of course, sterile dressings are advisable but in extreme cases it may be necessary to use nonsterile material

Positive pressure (tension) pneumothorax can develop rapidly after trauma to the chest but it is not as much of an emergency as a sucking wound During the course of an hour or more, symptoms of increased pressure in the chest may become apparent, by which time proper first aid measures under suitable conditions usually should be at hand True tension pneumothorax is found infrequently

The patient should be prevented from any exertion which would place an additional strain on the already impaired respiratory system

Transportability In the absence of a positive pressure pneumothorax or a nonoccluded sucking wound, thoracic injury cases withstand transportation comparatively well (They fare better in this regard than do abdominal injuries with a perforated hollow viscus) The longer the delay from injury to definitive repair the greater the chance of infection Moderate periods of delay after six or eight hours are seemingly not detrimental according to some reports [1]

Diagnosis Although determining the sites of damage in a thoracic injury is not difficult in those caused by direct violence it is much harder to conjecture correctly the state of affairs intrathoracically in terms of the amount of lung damage and other structures injured in the path of the wounding agent Should the wound be due to a bullet or a fragment that has traversed the chest, one can estimate the damage by lining up the two wounds and mentally plotting the course Also in those in-

stances of injury by a metallic foreign body that has penetrated the thorax, the probable path can be determined by the same method after proper localization of the retained foreign body by roentgen examination. Various more or less elaborate methods have been developed for such localization,[2] but in most instances the posterior-anterior and the proper lateral x ray views will suffice In certain instances especially late in convalescence where precise localization of small foreign bodies is desired, fluoroscopy followed by the proper oblique projection films will determine the localization with considerable accuracy The various procedures of foreign body localization such as pneumothorax, pneumoperitoneum and electrical methods of localization, are not germane to this discussion of early treatment. Accuracy of diagnosis is of special importance in cases where there may be a thoracoabdominal injury or in instances of damage to the esophagus, since both conditions are indications for thoracotomy

The wound of entry or exit, especially the former can be very misleading so far as the amount of intrathoracic damage is concerned A smooth metallic object, such as a bullet, may leave a quite innocent appearing wound of entrance If the missile is irregular or if it travels at high velocity and strikes a rib on the way in it may produce great damage mainly from the force transmitted to the fractured irregular fragments of bone The bone fragments very often do much greater harm than the missile itself Wounds of exit (when present) are a better criteria of the state of the damaged lung than the wounds of entrance They are always larger than entrance wounds due to the expanding force of the missile but are more nearly comparable to the lesions in the traversed lung

Any injury or accident producing a chest wound may also cause damage in other parts of the body This is true of civilian accidents and war time injuries Experience in World War II[1] indicated that approximately twenty per cent of those sustaining major chest injuries had in addition at least one associated major wound. Those patients with associated major wounds, had a mortality rate of twenty-eight to thirty per cent compared with a rate of ten to twelve per cent for those in whom a thoracotomy only was necessary thus approximately doubling the mortality rate

All thoracic injuries need not show external evidence of violence This is especially true of crush injuries such as those caused by a wall crumbling on a person. Blast injuries from the pressure wave near any explosion can produce marked pulmonary damage [1] Whether this shock wave causes the intrapulmonary hematoma by the force striking the chest wall or by being transmitted through the air column in the trachea and bronchi has not been definitely determined, but the former is more likely than the latter The lesion it causes however is quite characteristic Similar damage to intestine kidney etc., has been observed.

As soon as possible after injury the patient should have a carefully performed physical examination to determine the extent of the lesion and also to ascertain the presence of any other associated injury The major injury may draw most of the attention and associated fractures or injuries not in close proximity to the main one may be over looked. It is *especially* important that the back be inspected adequately in-

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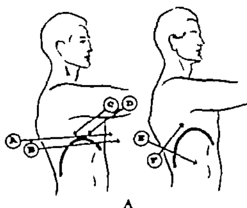
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cluding the buttocks Possible injury to the spinal cord should be looked for A careful physical examination by one person is far preferable to a "quick look" by several the latter only increases the risk of infection in the wound and allows more air to enter any sucking wound that may be present

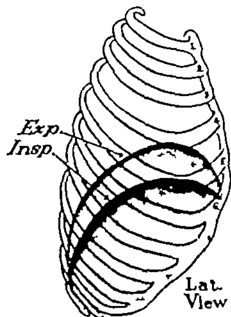
If the patient is conscious additional questions as to how the injury was sustained will often give useful information Such items as how near he was to the explosion, when that is the type of injury when he had last eaten food whether he had been unconscious or not, and the location and severity of pain are all important. Vomiting is not frequently associated with thoracic wounds and its presence should suggest injury in the abdomen as well.

The two factors to be looked for first are cyanosis and the position of the mediastinum The first can usually be determined readily unless the patient is badly exsanguinated. The second is checked by the position of the trachea in the suprasternal notch or the position of the apex beat of the heart. These signs of the position of the mediastinum are reliable enough for the first quick appraisal to determine resuscitative measures When a more adequate examination is possible on admission, as in the not so severely injured a careful examination is in order at once

If the examiner has questioned the patient regarding the circumstances at the time of injury the position the patient was in and just what he was doing at the time it will be helpful in evaluating the path of the missile Many supposedly bizarre courses of foreign bodies are not so bizarre in the light of complete knowledge of the patient's position The second important consideration is the position of the diaphragm Although this muscle attaches to the lowest part of the thoracic cage it rises in its central portion to the level of the fourth rib or third



A



B

FIG. 1A Diagrammatic representation of the paths that missiles may take in close proximity to the diaphragm. The wound of entrance is not of as great importance as the direction of travel. B Diagrammatic representation of the diaphragm in inspiration and expiration. Any foreign body traversing the chest below the level of the fourth rib anteriorly may possibly have injured the diaphragm. (J Thor Surg., 15 350 [Oct.] 1946. Courtesy of C. V Mosby Co.)

interspace anteriorly during expiration (Fig 1) Thus it may have been traversed by any missile crossing this sector of the thorax Any injury below the third interspace anteriorly or the seventh rib posteriorly may have produced abdominal injury as well as thoracic.

Possible injuries to mediastinal structures are usually not too difficult to diagnose A laceration or rupture of the trachea or large bronchus is apt to produce positive pressure pneumothorax. Injuries of the esophagus may be suspected if blood is aspirated through a Levin tube. Patients with lung injuries often swallow blood from the lung so this may be misleading In occasional instances lipiodol may be swallowed or injected in the esophagus for confirmation. Barium should not be given in suspected esophageal lesions of a traumatic type Widening of the mediastinal shadow especially soon after injury is more apt to indicate a hematoma rather than an early mediastinitis

Injuries to the heart and great vessels are discussed in Chapter 17

RESUSCITATION

Shock The degree of shock that is exhibited by patients with traumatic injuries to the chest varies greatly from case to case. Most patients however with any major injury to this region will exhibit either frank shock or signs of impending shock. This may be due to actual loss of blood itself to cardiorespiratory imbalance, or to a combination of the two Various other factors, such as infection which is of great importance in abdominal injuries but less important in the thoracic type may be contributive

In the period immediately following injury the thoracic patient s greatest danger is from anoxia. It makes no difference, as far as the effect on the patient is concerned, whether the anoxia is due to loss of blood itself fluid from the circulatory system reducing the effective blood volume pulmonary embarrassment from large collections of blood or air in the pleural space or an obstructed airway from blood or mucus All these tend to decrease the efficiency of oxygen absorption and utilization, hence lead to varying degrees of anoxia. The objective therefore of all resuscitative measures is to restore the physiologic equilibrium. Inasmuch as blood loss is a major factor in most injuries of the chest, it is important that the deficit be corrected as rapidly as possible. In those cases where blood loss is a major factor nothing can replace whole blood as a means of restoring the circulating blood volume In these days of blood banks there should be little difficulty in civilian practice in securing adequate amounts of blood although it may take more time to obtain it than one is justified in waiting. In those instances when blood is not readily available, or while blood is being crossmatched, plasma may be used in reasonable amounts, or in the absence of that, one of the electrolyte solutions, although the electrolytes are the least acceptable. In emergency instances where a patient is in a marked degree of shock with a very low or unobtainable blood pressure it is perfectly justified to give group 0 blood without waiting for the result of the cross matching. It is never advisable, however to give blood without crossmatching in any other than emergency conditions. The amount of replacement therapy that is necessary will depend

entirely upon the patient's need It has been amply pointed out that large amounts of intravenous fluids should not be given rapidly to patients who already have disturbed cardiorespiratory mechanisms. If an attempt is made to estimate the amount of blood loss and to replace this quantitatively there will be no difficulty on this score. The main pitfall is in trying to raise the blood pressure and lower the pulse rate by giving large amounts of blood when the actual state of the patient is due to embarrssment of the lungs from a large collection of fluid or air in the chest or an inability adequately to oxygenate the blood through an airway that is partially obstructed. Probably as many thoracic cases die of mechanical difficulties in the immediate post injury period as succumb to actual blood loss itself Attention to the mechanics of respiration is a prime requisite in all instances

If human albumin is used to restore the circulating blood volume it should be remembered that this preparation and others like it have the property of drawing into the circulation large amounts of extracellular fluid. In this way they do tend to restore the circulating blood volume but they do not increase the oxygen carrying capacity of the blood per cc but tend on the contrary to reduce it. They are therefore of value in the early stages of treatment before whole blood is available and in instances where the diminished circulation may be due to vasodilatation and diminished cardiac return

Besides blood loss, hemopneumothorax, pain and an obstructed airway are the most important shock-producing factors in patients with thoracic wounds Only in those instances in which there is a thoracoabdominal injury with contamination from injury to a hollow viscus does the infection factor assume much importance in the early care of such patients Hemopneumothorax of some degree is present in practically all major chest injuries and attention to its alleviation is of prime importance. As a rule, as soon as replacement therapy has been started attention should be directed to removing collections of air blood or both from the pleural space In favorable instances where there has been minimal contamination and where blood for transfusion is limited in supply the blood aspirated from the pleural space can be used as an autotransfusion

Blood that collects in the pleural space for the most part comes from the chest wall or from the lung Bleeding from injuries to any but the larger vessels at the hilum tends to cease spontaneously The pressure in the lesser circulation being so much less than in the systemic circulation it is not usual for the lung to continue bleeding over any prolonged period. Vessels in the thoracic wall, however may bleed quite severely This is especially true of any vessel that has been only partially divided Those that have been completely severed can retract and have a better chance of clotting

With the fall in blood pressure that accompanies marked blood loss clotting in the severed vessels will usually take place and the bleeding cease. There are instances, however where bleeding has continued from the chest wall vessels producing such a profound state of shock that the patient could not be resuscitated. Such cases are decidedly in the minority and it is usually safe to assume that such bleeding will

cease but the patient must be kept under careful observation

Thoracentesis Inasmuch as some degree of hemothorax is present in most cases of chest injury thoracentesis is of prime importance in restoring normal cardiorespiratory dynamics The older teaching was that blood should not be removed from the pleural space early in the postinjury period for fear of producing more bleeding from the lung as it reexpanded. This theory has been found to be incorrect as very little bleeding actually takes place from the lung in most instances and it is not conceivable that the pressure created by the fluid in the pleural space would be effective in checking bleeding from a systemic chest wall vessel.

In those instances where there is damage to the large vessels in the pulmonary hilum the patient most often expires in a matter of a few minutes before anything more than first-aid can be administered. It is therefore a safe procedure to remove blood or air from the pleural space any time after injury The amount that can be removed safely at one time has never been determined, but a good working rule is that any amount can be removed unless the patient experiences discomfort. Usually the shifting of the lung and mediastinum attendant on the removal of 1200 to 1500 cc. of fluid or air will cause the patient enough unpleasantness that he will indicate that it is causing him discomfort. In such instances the thoracentesis should be terminated and the patient aspirated again after a period of several hours

It should be pointed out in connection with thoracentesis that it is not always necessary to aspirate the chest in the classical infrascapular location, although the posterior part of the chest is a good place for aspiration In an acutely injured patient, especially if he is getting replacement therapy it is often inconvenient to have the patient sit up or lean over a bench in order to carry out aspiration posteriorly The pleural space can be evacuated almost completely by aspirating low in the axilla. This maneuver can be done with the patient supine and without disturbing him by unnecessary movements

In those instances that are accompanied by considerable hemothorax, but without indications for a thoracotomy aspiration of the pleural space should be carried out as often as necessary to keep it comparatively dry Not only should all blood, fluid, and air be removed to prevent the formation of a hemothorax, but also it is advisable to get the lung completely reexpanded as rapidly as possible If a major operation is not necessary the evacuation of the pleura can be accomplished by thoracentesis No hard and fast rule can be laid down, but a good working dictum is to aspirate the chest every day as long as 100 cc. of fluid can be obtained. When larger amounts than this are obtainable, bi-daily aspirations are indicated. When less than 100 cc. can be obtained aspiration can be changed to every second day and sometimes to longer intervals

Marked degrees of shock are of course, easily recognized. Recognizing early signs of shock or as it has been called, incipient shock is not always so easy Towery[1] states "the recognition of incipient shock depends largely upon evidence of decreased peripheral flow (color and coldness of the skin and extremities collapse or constriction of the superficial veins and a pulse

of poor volume) The degree of these changes may vary considerably from patient to patient but is of extreme importance in indicating that a reduction of the circulating blood volume has occurred because of the level of the blood pressure" It is in this type of case without frank shock that comparatively small amounts of blood or other measures to increase the circulating blood volume may be of extreme value in preventing a deeper stage of shock from developing.

Maintenance of Airway· The picture of surgical shock is not always due to just blood loss alone, as is well recognized One of the more potent factors in the production of this clinical picture is anoxia. The initial response to anoxia in the absence of other factors, is often an increase in blood pressure but when the patient is already in a state of incipient shock, anoxia may be the factor that puts the patient into profound shock Mention has already been made of the necessity for removing collections of fluid or air from the pleural space in order to increase the efficiency of the functioning pulmonary parenchyma One of the most frequent causes of deficient oxygenation of the blood is partial obstruction of the airway In traumatic thoracic cases it is most often due to a collection of blood or mucus in the tracheobronchial tree Effective clearing of the airway is often prevented by pain which makes it difficult for the patient to cough effectively and to bring up any material that is present. In an injury of the chest of any severity the two factors of pain and excessive material in the tracheobronchial tree are apt to be present Practically all penetrating or perforating wounds as well as those that only damage the chest wall if they are of much severity produce some bleeding into the lung with formation of a hematoma Blood from this area then gets into the bronchi and has to be expectorated if a clear airway is to be maintained.

Accompanying the trauma to the chest there is also a reflex secretion of mucus or thin watery fluid into the bronchi much as edema follows an injury to other parts of the body This condition has often been referred to in the literature as "wet lung."[3,4,5] There is no unanimity of opinion regarding the exact method of its formation, but there is no doubt that a large amount of bronchial secretion is formed in the presence of a severe injury of the chest.

The best way of clearing the tracheobronchial tree is by the patient's cough. In the presence of severe pain or when the patient is semicomatose, this method may not be effective The pain factor should be relieved as quickly as possible by a paravertebral procaine infiltration of the affected intercostal nerves and two or three nerves on either side of the injured area This method is much more effective than administration of large doses of morphine[6,7] Firm support to the lower costal margins also splints the chest effectively and permits a more efficient cough to be executed painlessly This can be provided sometimes by a tight binder (which is applied only periodically to help the patient cough and not left in place as it may obstruct adequate respiratory movement) In other instances support can be obtained by placing the hands on either costal margin and giving support during the expulsive effort.

In spite of all such aids it is often true that the patient is still unable to clear out completely the material from the airway In such cases

aspiration of the trachea and major bronchi can be carried out easily with the use of a No 14F or 16F urethral catheter The catheter can be introduced into the trachea through a nostril after the manner described by Haight[8] (Fig. 2) The catheter is then connected to a source of suction and all material removed in this manner By turning the patient's head first to one side and then to the other the catheter usually can be made to enter the opposite main stem bronchus and in this way the main bronchi as well as the trachea are aspirated. The presence of the catheter in the bronchus is such a marked stimulus to cough that most patients will cough even though it is painful at the time The patient should be encouraged to cough during the aspiration as this effectively brings material up to the range of the catheter that would not be obtained otherwise In severely dyspneic patients or those that have their pulmonary functions badly crippled, care should be exercised not to produce more anoxia by the aspiration If it is found that anoxia is increasing as evidenced by cyanosis or prolonged bronchial spasm, one should break the suction until proper oxygenation has again taken place It has been found advisable to cut a small hole in the proximal end of the catheter so that the hole can be periodically occluded with the finger tip thus providing intermittent suction. This also facilitates the introduction of the catheter as it will move along the airway more easily when suction is not being applied. Only rarely has it been found that catheter aspiration was not successful and bronchoscopy had to be employed Facilities for bronchoscopy should always be at hand, but it is rare that a bronchoscopy need be carried out in either the preoperative or postoperative period if catheter aspiration of the trachea and bronchi is practiced.



FIG. 2. Drawing illustrating the introduction of a catheter into the trachea by the "blind" procedure. When the patient lies flat in bed, with the neck slightly extended, a catheter introduced through a nostril can ordinarily be made to pass between the vocal cords during inspiration or when the patient coughs. After a little practice with this procedure it is very rare that it is necessary to expose the larynx with a laryngoscope for introduction of a catheter

In some patients that are severely injured and especially those with large amounts of mucus in the tracheobronchial tree and in instances when the patient is comatose, aspiration is indicated as often as every ten or fifteen minutes for the first few hours In patients who are unconscious, or practically so an endotracheal tube can be introduced and left in place and through this the catheter can easily be *inserted* as often as necessary Oxygen is given through the tube between aspirations

Relief of Pain Providing a painless cough reflex is one of the more important points in the early care of the thoracic casualty For the most

part, pain is not severe in chest injuries in the absence of fractured ribs but as most severe injuries are accompanied by the fracture of one or more ribs pain is often rather severe The discomfort can of course, be controlled by large enough doses of morphine, but the depressive effects of morphine should be avoided especially in thoracic casualties as every effort has to be made to improve rather than diminish the degree of oxygenation Large doses of morphine therefore are to be avoided The lung itself being insensitive *if chest wall pain is abolished,* coughing can be carried out without undue discomfort. Blocking of the intercostal nerves[8 9 10] by procaine one per cent or 0.5 per cent will produce long periods of effective anesthesia This blocking may be done at any point central to the wound, but in the majority of instances the most satisfactory site for injection is paravertebrally where the nerves are easily located Three or four cubic centimeters of procaine injected in the immediate vicinity of the intercostal nerve will produce lasting anesthesia for a period of hours and in many instances it will last as long as six to twelve hours The injection can be repeated as often as necessary

Great care should be used in administering morphine to patients in deep shock [11] This is especially true of subcutaneous injections as oftentimes the sluggish circulation does not pick up the drug and consequently a further dose may be given with a cumulative effect, once the circulation has improved. It is far better if morphine is going to be used and proper personnel are available to administer it, that it be given in smaller doses intravenously and repeated more frequently rather than to give large doses subcutaneously

Oxygen Therapy As mentioned above prevention of anoxia is one of the chief concerns of the preoperative management of chest injuries There should be no hesitation in administering oxygen if there is the slightest indication to do so Theoretically a mask is a more efficient method of oxygen administration but practically it has been found that four or five liters (quarts) per minute given through a catheter introduced into the nasopharynx is better from a practical standpoint. Many patients do not tolerate *the presence of a mask and if they are* somewhat semiconscious they may be very uncooperative in keeping the mask in place. Oxygen administration should be continued until there is no longer any doubt about adequate oxygenation of the blood

Patients with respiratory impairment often are able to breathe better and feel better subjectively if the head and shoulders are slightly elevated In the absence of marked shock the thoracic casualty should be allowed to have the head and shoulders elevated to a comfortable position and not necessarily be kept with the body flat or the feet elevated as is usual in caring for shock cases.

Gastric Dilatation Gastric dilatation is a frequent accompaniment of any severe wound. It is found practically as often in the thoracic patient as in the abdominal casualty [1] Various factors may contribute to this finding In war casualties where the patient may have been under severe nervous strain and tension for a period of hours before injury took place it is not unusual for the stomach to fail to empty its contents even though the last meal may have been eaten many hours before During the height of a battle we have

seen many instances where the stomach was almost completely filled with food even though the last meal had been eaten some six to eight hours before wounding Likewise after wounding, peristalsis is also greatly diminished or absent and the material does not escape into the lower intestinal tract. In thoracic casualties the pain and discomfort that attend breathing when there are fractured ribs seem to impede normal emptying of the stomach. It is a wise plan in all severe thoracic injuries to introduce a stomach tube preferably a large one, to evacuate the stomach if it is suspected that food is still present. If the gastric dilatation is simply due to air then a small Levin tube works satisfactorily In any event, attention should be paid to relief of gastric dilatation. In patients with anoxia the elevation of the diaphragm from a large distended stomach may be an important factor in continuing the anoxia state.

Chemotherapy· The chemotherapeutic agents are valuable in preventing clinically apparent infections following traumatic injuries to the thorax. They should be used in every instance where more than a minor injury has taken place. At the present time penicillin is the logical antibiotic although it may soon be superseded by aureomycin or one of the other drugs with a wider spectrum. Where cost is not a factor aureomycin or terramycin is probably preferable. For the routine casualty penicillin which is so readily available and economical may be employed. Large doses at the outset are of more value than small doses for a longer period of time In those instances where there may be rather severe pleural contamination, depending upon the type of injury and especially in those where there may be a thoracoabdominal wound with intestinal contents contaminating the pleura penicillin 500 000 to 1 000 000 units should be given intravenously at the time replacement therapy is started. The drug can then be continued subcutaneously throughout the remainder of the preoperative and postoperative period until the danger of infection is past.

The local use of the sulfonamides has been abandoned, but there is still place for the use of antibiotics in local conditions In instances where the pleural cavity is not being drained immediately or can be drained only intermittently 500 000 to 1 000 000 units of penicillin and a gram of streptomycin can be left in the pleural space The thoracic wall wound itself does not usually need local application The beneficial effect of chemotherapy can be obtained in the local wound by intramuscular injection better than by local application.

When large amounts of chemotherapy have been employed, infectious complications in the postoperative period may be overlooked due to the masking of symptoms by the chemotherapy Surprisingly large collections of purulent material may occur without the patient exhibiting the usual signs of acute infection, as the toxicity of the organisms are held in abeyance by the antibiotic. It must be emphasized that the danger of complication is not past until a normal lung is in apposition with the chest wall and the pleural space has been obliterated As long as abnormality can be demonstrated by roentgen examination of the chest, infectious complications are a possibility

TRANSPORTABILITY

It has been amply demonstrated that thoracic traumatic cases without serious disturbance of the cardiorespiratory

physiology or those whose cardiorespiratory balance has been restored by proper first aid measures with evacuation of the pleural space and the closure or occlusion of any sucking wounds that may be present, need not be operated on at once. In fact, a period of time up to a few hours for stabilization after cardiorespiratory physiology has been restored is often beneficial rather than detrimental to the patient. During this period the patient can be transported without difficulty if such is indicated As discussed above it is better to defer definitive surgical treatment for a matter of hours in order to have it carried out under proper conditions and with adequate personnel than it is to emphasize the time factor unduly and carry out the surgical repair under improper conditions Such considerations are not of great importance in the usual civilian injury but are of great importance in planning the proper evacuation and care of the thoracic casualty in war time Nothing is to be gained by delay in surgical treatment after cardiorespiratory balance has been achieved but the threat of infection is not great enough to warrant hurried improper surgery under inadequate conditions

Transportation of the patient by air after a thoracic injury is usually a safe procedure[12] Small degrees of pneumothorax are not of great importance. If there is a continuing leakage of air into the pleural space an intercostal tube can be inserted for under water drainage. In indicated cases this is an important maneuver but it should be avoided in the absence of specific indications as experience in World War II and the latest reports from the Korean War theater[12] indicate that complications are much higher in the group that has had a tube inserted before being evacuated to the thoracic center

ANESTHESIA

Anesthesia for the débridement and closure of chest wall injuries that have not penetrated the pleura differs in no way from anesthesia given for a similar wound in other parts of the body except inasmuch as the patient may have been subjected to the effect of a blast wave or the underlying lung may have been damaged from the force of the blow against the chest wall even though the pleura was not penetrated In such instances hematoma formation takes place and there may be excessive amounts of blood or mucus in the tracheobronchial tree as was previously mentioned in the discussion of wet lung Procaine nerve block and local infiltration make a very satisfactory type of anesthesia for wounds of the chest wall When properly administered operative procedures can be carried out without disturbance to the patient and without upsetting the physiological equilibrium by a general anesthetic Only rarely however is a patient presented with a single wound and where multiple procedures need to be done the time consumed by multiple nerve blocks is not worth while and general anesthesia is preferred.

Anesthesia for intrathoracic operations or any procedure that may entail entering the pleural cavity is an important matter In caring for traumatic lesions of the chest it is very probable that the anesthetist is actually a much more important member of the operating team than the surgeon In fact, it has been said[11] that "a well qualified anesthetist can support an inexperienced surgeon better than a brilliant surgeon can maintain an inexpert anesthetist" The particular anesthetic agent that is used is of far less importance than the knowledge and skill of the one who administers it Not only does the anesthetist have to maintain the proper plane

of anesthesia but it is also his responsibility to maintain a clear airway for proper oxygenation and to supervise the replacement therapy that in most instances has to be carried out concomitantly with the operative procedure Endotracheal intubation is by far the most satisfactory type of anesthesia [13,14] It is possible to use an airtight face mask and administer the amount of positive pressure that may be indicated but there is no reason to omit the plac ing of an endotracheal tube which is so easily and quickly done by a well qualified anesthetist. As most of the pa tients have excessive amounts of trache obronchial material, aspiration during anesthesia can be carried out satisfac torily only through an endotracheal tube Positive pressure anesthesia is not often indicated and there seems little reason to use controlled respiration However assisted respiration is often necessary in order to keep the lung in the proper degree of expansion and to provide adequate oxygenation of the blood.

It is decidedly helpful if the anesthe tist is also experienced in carrying out aspiration bronchoscopy as this is the surest method of cleansing the tracheobronchial tree at the end of opera tion.[11,15] This should not be a routine procedure as proper aspiration through the endotracheal tube when it is re moved is usually all that is necessary but where difficulty is experienced or where there is some doubt regarding the state of the airway bronchoscopic inspection and aspiration should be used

BASIC OPERATIVE CONSIDERATIONS

"The surgeon's primary interest at operation is the restoration of a func tioning lung which is fully expanded against an intact or restored thoracic wall."[1] Thus attention is directed first of all to the restoration of function of the lung, which means removal of blood and air from the pleural space which hampers function by collapsing the lung and also providing an adequate airway for gaseous exchange. The lung can function efficiently and at its best only when fully expanded and therefore one should attempt to achieve this as rapidly as possible Secondly function is only satisfactory when the chest wall is either intact or has been restored. Thus, all pleural defects must be closed and sta bility of the thoracic cage achieved. Thirdly prevention of infection is the other objective of surgical treatment of thoracic injuries. This applies largely to the wound itself unless there has been a thoracoabdominal injury with con tamination of the pleura from the intestinal tract. If all foreign material is removed from the pleural space and the lung expanded, the problem of infection is very largely overcome

Although it has been stated above that thoracic cases withstand transporta tion comparatively well they do not withstand rapid, radical changes in posi tion of the body especially if there are large amounts of fluid or air in the pleural space and if the patient is in any degree of shock. In all preoperative manipulations of the patient, including the physical examination, roentgenological studies, and placing him on the table in the operating room, great care should be exerted not to shift the patient suddenly especially one that has recently been in serious shock, as the mechanical disturbance of the circulation may be very detrimental. In this regard it is well to point out that the initial physical examination should be carried out by cutting the clothes from the patient rather than rolling him

long time in clearing up Wounds that have been left open in the absence of developing infection can be closed by a secondary suture in five or six days with little loss in time of healing [1] When the pleura has been injured it is often necessary to carry out primary closure of the thoracic wall wound in order to obtain a satisfactory closure of the pleura

Repair of extensive chest wall defects which practically always involve loss of pleura is discussed below

INDICATIONS FOR THORACOTOMY

There has been a great deal of discussion in the literature,[10 11 16] especially during and shortly after World War II in regard to the indications for thoracotomy Precise statements cannot be made in this regard as conditions vary too widely depending upon the local situation Many factors enter into a decision as to the advisability of a thoracotomy in the early postinjury period. Among them are the general condition of the patient, associated other injuries, the availability of adequate anesthesia and operating facilities as well as suitable personnel If one considers the exigencies of war surgery other factors, such as the pressure of *the number of patients needing treat*ment, the distance to the nearest hospital to the rear etc., are of considerable significance

When adequate facilities and personnel are at hand a larger percentage of patients will and should be treated by thoracotomy than where only meager facilities are available. There are certain definite indications however that can be stated categorically

1 Large chest wall defects by which it is understood that sections of more than two ribs and adjoining pleura have been destroyed These are really traumatic thoracotomies that is, when one débrides the wound that is present there is already an opening into the chest sufficiently large to carry out any indicated intrapleural procedure

2 Possible thoracoabdominal injury especially when the suspected abdominal injury is in the left upper quadrant of the abdomen Lesions in this area are much more easily treated surgically through the diaphragm than they are from below In the presence of injury to a hollow viscus in the abdomen, infection can gain entrance to the pleural space and therefore such cases should be explored as early as resuscitation can be accomplished Any delay beyond that necessary may increase the factor of infection

3 Miscellaneous indications Under this category are numerous indications but all of them are of very low incidence Among them can be mentioned

(a) Continued severe intrapleural bleeding This will usually be found to come from the chest wall itself but it may not be possible to check it without opening th- pleural space

(b) Possible injury to the esophagus

(c) Suspected damage to the heart or adjacent large blood vessels that *might* be amenable to treatment. (This is discussed in a separate section)

(d) Removal of excessively large foreign bodies In most instances such foreign bodies will have produced a traumatic thoracotomy in passing through the thoracic wall

In a series of 2267 penetrating and perforating injuries of the thorax, excluding thoracoabdominal wounds, treated by the 2nd Auxiliary Surgical Group[1] during World War II 435 thoracotomies were performed In 156

they were traumatic thoracotomies and in 122 others there was a questionable thoracoabdominal injury In other words these two indications comprise the bulk whereas the numerous indications in the miscellaneous class even when added together are a comparatively small group If proper facilities are available many more thoracotomies will be done as primary procedures in order to lessen the chance of any postoperative difficulty or late surgical procedure being necessary Where facilities are not good the tendency should be to do as few thoracotomies as possible, realizing that reparative surgical procedures may be necessary during the convalescence period Likewise, there is no unanimity of opinion regarding what constitutes a thoracotomy Technically any operation which exposes the intrapleural space is a thoracotomy Thus the simple débridement of a penetrating or perforating wound is technically a thoracotomy inasmuch as the rent in the pleura is exposed and in fact quite often some intrapleural manipulation is carried out even through a small rent in the pleura such as introducing a catheter and aspirating blood and air from the pleural space at the time of operation This is obviously a far different procedure than a formal thoracotomy for extensive damage to the chest wall and intrapleural structures All definitions are therefore somewhat comparative

It should be emphasized that such things as small foreign bodies lacerated or contused lung, or a hemothorax are not in themselves indications for the formal opening of the chest although all these things should be taken care of as much as possible if an intrapleural procedure has to be carried out for other indications One of the more frequent reasons given for thoracotomy soon after injury has been that of continued bleeding This is an indication when such is present but all evidence points to the fact that this is not often The surgeon should have some general idea, however of what in his mind constitutes continued intrapleural bleeding necessitating thoracotomy In World War II the following criteria were used as an indication of continued intrapleural bleeding sufficient to warrant thoracotomy [1]

1 "A blood pressure which fails to rise with apparent adequate blood transfusion in amounts as high as 2500 cc. or having risen to relatively normal levels falls again.

2. Reaccumulation of 1500 to 2000 cc. of blood in the pleural cavity within twenty-four hours of the initial aspiration of a similar large amount

3 Persisting severe anemia in spite of blood replacement as determined by serial hematocrit readings "

This proved to be a good working rule for wartime conditions but under more favorable civilian situations this could be modified somewhat and thoracotomy carried out for lesser degrees of bleeding

The incisions used for thoracotomy again are subject to wide variation In traumatic thoracotomies the incision, by definition involves the wound as in the main the only indication for thoracotomy is an adequate débridement of the wound When the indications for exposure of the intrapleural space are other than a traumatic thoracotomy due concern should be paid to the proper placement of the incision to give the maximum exposure and the least disturbance of the patient's physiology

It is recalled that the second most indication for a thoracotomy is

a suspected thoracoabdominal wound it is obvious that proper exposure will be obtained only when the incision is placed comparatively low in the thorax. In such instances the wound or wounds of entrance and exit should largely be ignored and the incision placed so as to give maximum exposure to the suspected area of injury An incision through the bed of the 8th rib or through the 8th intercostal space gives a good exposure to lesions in the upper quadrant of the abdomen When a formal thoracotomy is to be done for other than a traumatic defect it is usually through the fifth or sixth intercostal space posteriorly which will allow the surgeon to deal with almost any lesion in that hemithorax It need not be emphasized in this discussion that if a thoracotomy is to be done there is no point in limiting the extent of the incision, proper exposure is of utmost importance and there is very little excuse for working through an inadequate exposure

SPECIFIC TREATMENT

Tension Pneumothorax True tension pneumothorax, or pressure pneumothorax, as it is sometimes known, is less common than one would believe from the emphasis it is given in the literature It is true, as has been shown by Shefts[17] and others that if one takes the intrapleural readings in any case of injury to the lung with hemopneumothorax the readings will indicate a pressure above zero in expiration in a high percentage of cases. This is probably due to the space occupied by the blood and air and to the grunting type of respiration so often found in patients with thoracic pain. It has also been shown that in some instances of pulmonary edema, or "wet lung" the patients themselves discover that they are more comfortable and breathe easier if they exhale against a slight resistance and they sometimes do this spontaneously by exhaling through pursed lips All such maneuvers as this tend to raise the intrapleural pressure A true tension pneumothorax is one in which the pressures are markedly elevated with both inspiratory and expiratory readings on the positive side To obtain such pressures, either a large bronchus has to be ruptured or some valvular mechanism must be present to allow easier ingress of air to the pleural space than egress The usual leakage of air from the lung following penetration of a foreign body or puncture by a fractured rib only rarely produces tension pneumothorax.

If such a condition does exist, as evidenced by marked respiratory distress shifting of the mediastinum and rapid reaccumulation of air after thoracentesis, prompt treatment of the condition is indicated. Before facilities are at hand for definitive treatment the best temporary measure is to insert a catheter preferably a 14F or 16F into the chest intercostally usually in an interspace high in the axilla as air tends to collect in the upper anterior part of the chest. This catheter is then connected to a water seal, or if gentle suction is available, better yet it can be connected to the source of suction When a trocar is not readily available, a large gauge needle either a 14G or 16G can be inserted in a similar location and attached to a water seal drain

In instances where the tension pneumothorax is due to a leak from the lung parenchyma a period of a few hours to one or two days continuous drainage will, in practically every instance result in lung expansion. In

older individuals where an emphysematous bleb may have been ruptured a leak may persist due to the abnormal lung tissue Should the patient not respond satisfactorily and large amounts of air continue to come through the tube or if the volume of air that is leaking cannot be drawn off by the tube with gentle suction, it indicates that a large fistula is present and possibly an injury to the trachea or bronchus may be the source

Mediastinal Emphysema A small amount of air may gain entrance to the mediastinal fascial planes following any injury to the chest, especially if there has been a fracture of ribs and puncture of the lung As a rule, the amount of air that gains admission to the mediastinum is not large one of the exceptions however being a rupture or injury of the esophagus or major bronchus which has become sealed off from the pleural space In such instances the pressure in the mediastinal tissues may become so great as to impede venous return and embarrass the cardiac output. Almost any but the smaller degrees of mediastinal emphysema manifest themselves by the appearance of subcutaneous emphysema in the neck This may then spread down over the arms and chest and in instances of injury to a large bronchus the rapidity of the extent of the emphysema may be alarming Minor degrees of mediastinal emphysema such as leak in from the intrapleura pneumothorax, are of no clinical significance The time honored customary treatment of severe mediastinal emphysema is a transverse incision in the neck with development of the fascial planes down in the mediastinum for escape of the air No doubt this has been life saving in some instances but it is not indicated as often as it has been used and has not always been effective in relieving those cases in which it has been used. Mediastinal emphysema is mainly of importance in calling attention to a possible severe injury to the mediastinal structures and it is probably advisable to go ahead with thoracotomy in the presence of rapidly developing mediastinal emphysema rather than rely on a mere decompression through the neck In those instances in which the mediastinal collection of air is due to an injury of the lung with pneumothorax, decompressing the pleural space relieves the mediastinal emphysema very promptly

Injury to the Trachea or the Major Bronchi Such injuries both in wartime and in civilian practice are rare In war surgery missiles that produce an injury to the trachea or bronchus are apt to have caused other damage which results in a fatal issue before the casualty is even seen by a medical officer It takes a fortuitous set of circumstances to produce a major injury to the trachea or bronchus without severely damaging the neighboring large vessels and heart. All those with large experiences in war surgery however have seen from one to three or four instances where this has taken place. When a rapidly accumulating pneumothorax cannot be relieved by conservative measures and in the presence of mediastinal emphysema of marked proportions one should suspect injury to the trachea or bronchus and surgical exploration is indicated.

Whereas most all the war injuries of the major air passages are due to missiles practically all of the injuries to these air passages seen in civilian practice are from nonpenetrating injuries of the chest. In over half of the instances no ribs have been fractured Kinsella and Johnsrud[18] were able to collect

thirty-eight cases from the literature to which they added two of their own. Since that time several other cases have appeared[10] so there are in the vicinity of fifty cases that have been reported In most every instance injury has been a severe crushing type, most often the patient being run over by some type of vehicle and sustaining a severe crushing injury of the chest. In some cases multiple rib fractures have been present, but this is less common than to have no rib fractures

The exact mechanism of rupture of the bronchus which is usually the main stem bronchus just below the carina, is not well understood. The semirigid bronchi are apparently less resistant to trauma than the fluid filled large vessels in the immediate vicinity It is probable that at the time of the accident the patient unconsciously closes the glottis and thereby raises the pressure in the bronchus That tends to make even more rigid the bronchi which are then subjected to the shearing force of the chest being compressed rapidly in one direction The membranous posterior portion of the bronchus usually ruptures and frequently there has been associated fracture of the bronchial cartilages

In spite of the rather large tear that has been observed in ruptures of the bronchus a seemingly large number of them do become sealed over and the acute phase of the condition may pass unrecognized. From reports in the literature some fifteen cases in all have been recognized during the acute stage and all have recovered, thus emphasizing the importance of early diagnosis in such instances.

When the true nature of the condition is not recognized or is not treated, experience would indicate that most of them go on to a more or less complete stenosis of the bronchus and many of these patients have had to have pneumonectomies done later on for complete atelectasis of one lung When the bronchial obstruction is complete atelectasis may persist for many years without the development of bronchiectasis When the obstruction is incomplete and a stricture exists infection gains entrance and extensive bronchiectasis develops Scannell[20] has reported a case in which he operated within a few hours of injury and repaired the bronchus A good result was obtained Also Paulson[10] has operated on two cases of rupture of the bronchus, one of them being a late case having been injured ten years previously In this instance marked bronchiectasis had developed and a right pneumonectomy was done In his other case the patient was seen early after a crushing injury and a suspected rupture of the bronchus was considered The patient's quick response to pleural decompression seemed to be against this diagnosis However within a few weeks the patient began to show signs of atelectasis which became complete the day before operation. At thoracotomy evidence of an old ruptured bronchus was found and the stenosed area was opened up and repaired using a dermal graft. An excellent result was obtained.

Rib Fractures: Rib fractures are in themselves of little importance but may be of much significance as they relate to the efficiency of the cardiorespiratory system Little attention need be given to accurate approximation of fractured ribs or their firm healing by callous formation. This is usually accomplished without difficulty In several respects, however multiple rib fractures are of much importance In the first instance fractures of these bones give rise to

rather severe degrees of thoracic pain which in turn limits the respiratory excursion Severe chest wall pain from fractured ribs has been found to be a cause of incipient shock and often contributes to the generally poor status of a patient with a traumatic lesion of the chest due to improper oxygenation



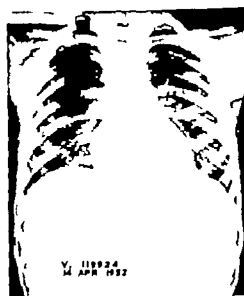
A



B

Also when multiple ribs are fractured especially if the same ribs are fractured in more than one place that section of the chest wall becomes flaccid and a varying degree of paradoxical respiration is always apparent (Fig 3)

One development of World War II has been a more rational treatment of fractured ribs Up to that time an attempt was made to relieve the pain by strapping, either applying wide bands of adhesive over the area of injury itself or the more effective method of one 7 5 or 10 cm. (3 or 4 inch) strip completely encircling the lower costal margin These methods do in some instances relieve the pain but only at the sacrifice of considerable pulmonary function It has been shown conclusively



C

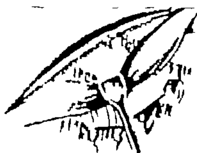
Fig. 3A Roentgenogram of patient on admission to hospital after a fall of 6 meters (18 feet) There were multiple rib fractures and a hemopneumothorax on the right. This is a common association of findings in direct trauma to the chest. B The same patient a few hours later following thoracentesis and catheter aspiration of the trachea and bronchi. C Roentgenogram of patient ten days after injury at time of discharge

in many studies both during the war and since that the logical treatment for pain of fractured ribs is a paravertebral procaine block. In some instances one injection alone will suffice, whereas in others it may have to be repeated two or three times a day for twenty four or forty-eight hours Certain surgeons[0] are now investigating the possibility of fixing multiple rib fractures by wiring the fragments This has not become an accepted surgical procedure as yet and it is believed that relief of pain is the most important factor with other surgical procedures being used only when the stability of the chest is so greatly disturbed that respiration cannot be carried out adequately The cases that give the most difficulty from paradoxical respiration are those with multiple rib fractures or a fracture of the sternum, the latter being more often the cause than the former Although the Drinker respirator should be effective in controlling such cases it has not been as helpful as was expected. The muscles are not paralyzed as in poliomyelitis and hence it is difficult for the machine to take over the function of respiration Fixation of the fragments for a few days will often permit sufficient stabilization to take place so that no further difficulty will be experienced The use of a towel clip or a cervical tenaculum[0–1] gripping the sternal fragment or a fractured rib and then attached to a 1 8 or 2.2 kg. (4 or 5 pound) weight over a pulley will often give dramatic improvement.

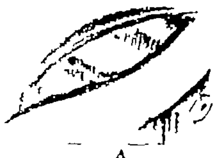
Intrathoracic Foreign Bodies. Whether or not an intrathoracic foreign body should be removed soon after injury will depend upon the circumstances Obviously if a thoracotomy is being done for some other reason any accessible foreign body should be removed The presence of a foreign body as an indication for a thoracotomy in the early postinjury period is not frequent. As most intrapleural foreign bodies will be found in wartime casualties a discussion of this point must be related to wartime surgery and, as indicated previously when the pressure of casualties is high it is not advisable to carry out thoracotomy for any except excessively large ones in the forward medical installations Such situations can be handled more easily and safely in a reparative center at the base When intrapleural foreign bodies are present in civilian casualties a decision will have to be made on individual grounds Unless the missile is excessively large it is not in itself an indication for opening the thorax.

Foreign bodies that either may have traversed the mediastinum or lodged in the mediastinum are very often an indication for surgical visualization of the damage.[22] It is not so much the removal of the foreign body as to repair any damage that has been caused by the missile in its passage that demands exploration. Occasionally the esophagus or the thoracic duct will be injured and these should be repaired as early as possible Suspected or proved cardiac injuries are discussed elsewhere

Injury to the Lung. One is often surprised by the extent of the damage to a lung with surprisingly little disturbance in the patient's cardiorespiratory physiology Practically all injuries, especially those that have been caused by missiles of high velocity and those where ribs have been hit on the way in will show varying degrees of hematoma formation in the lung It is always a temptation on the part of those with little experience on seeing practically all of the lobe one mass of hematoma to



LOOP FLAP



A

PLUG FLAP with sutures set for expanding it within the defect



B



C



D



E

FIG. 4A to E. Diagrammatic representations of various method used to close defects in the chest wall by use of neighboring muscular structures. The pedicle flap Fig. C and E, is usually the most useful.

tion it is advisable to drain the space with two catheters, one posteriorly and another anteriorly or high in the axilla, the latter catheter being directed into the upper anterior part of the chest where air is most likely to collect Such drainage tubes are most effective when drained under water and then connected, as in Fig 5 with a source of gentle suction. As soon as the drainage ceases and the lung is completely expanded the tubes can be removed. Nothing contributes to the smooth convalescence of the thoracic casualty like proper evacuation of the pleural space and prompt complete lung expansion.

POSTOPERATIVE TREATMENT

Attention in the postoperative period is directed to securing the same essentials as mentioned previously under operative conditions, that is, the securing and maintenance of complete rapid, lung expansion and the maintenance of a free airway The third factor of prevention of infection is very closely related to the first two In those instances where the thorax has been drained with one or more tubes, these tubes should be led to a bottle and the tube immersed one or two centimeters beneath the level of the fluid. An air vent in the stopper of the bottle is essential to allow escape of air When possible gentle, continuous suction is advisable in addition to the under water drainage Attention must be paid to ensure that the nursing personnel understand the principles involved, as quite frequently inexperienced nurses will remove the drainage bottle for emptying without clamping the drainage tube beforehand This, of course allows air to enter the chest and may produce complications In the absence of experienced nursing personnel it is better for the surgeon to carry out any manipulations that are necessary to the drainage system Drainage tubes are only effective as long as they are patent and patency of these tubes should be checked at least once or twice a day

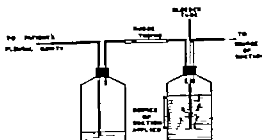


FIG. 5 Method of obtaining water seal drainage and constant gentle suction. The long tube in bottle (A) passes just beneath the water in order to provide a water seal type of drainage. The amount of suction that is applied to the system is regulated by the depth that the bleeder tube in bottle (B) is immersed below the level of the water Six to ten centimeters of water negative pressure has been found to be most satisfactory for pleural drainage.

When two tubes have been used, the one going to the apex of the chest to remove air can often be removed in twenty-four hours, as all air should have escaped by that time When there has been serious trauma to the lung there may be a continuous formation of pleural fluid over a period of three or four days The posterior drainage tube should therefore be left in place until fluid ceases to form In removing drainage tubes care should be exercised that air is not allowed to suck in through the hole If a piece of sterile gauze is applied as the tube is removed the defect in the chest wall can be sealed off at once and in the course of a few hours will become airtight. In those instances where drainage tubes have not been employed, or where they have failed to function efficiently and have had to be removed, both fluid and air must be removed in order to secure complete lung

expansion. Daily aspirations are indicated as long as at least 100 cc of fluid or air can be obtained at each thoracentesis.

Frequent postoperative roentgenological examinations of the chest are indicated and where possible the first portable film should be taken within twenty four hours of operation Thereafter films are not indicated often especially if fluoroscopy is available It is to be remembered however that the *status of the underlying lung must be* inspected by radiological methods at frequent intervals if complications are to be avoided.

As soon as the patient reacts from anesthesia efforts should be started to get the patient to cough and raise any material that may be present in the tracheobronchial tree All ward personnel including nurses orderlies and ward aids should be instructed in assisting patients in coughing by supporting the chest and thus relieving the pain In those institutions where a physical therapist is available valuable help can be obtained in encouraging the patient to cough and to carry out remedial breathing exercises in order to restore as quickly as possible the normal chest excursion In those instances where a patient is unable to raise effectively all the tracheobronchial secretions, assistance must be given by the use of steam inhalations with benzoin or other drugs and more frequently the aspiration of the trachea and bronchi by a catheter passed into the trachea through a nostril This is one of the most important methods of maintaining a clear airway In the occasional instance that such maneuvers are not completely effective bronchoscopic aspiration should be used Where facilities are available this can be done on the ward with the patient in his bed. Preoperative medication is unnecessary and usually the minimum of local anesthesia is used, as the main indication is to stimulate coughing and all that is desired is to relieve the discomfort of passing the instrument through the mouth and larynx It is a fairly safe rule to follow that if one considers the advisability of aspirating the trachea it is wise to go ahead and do it. It is far better to do a few extra aspirations than to leave an indicated one undone

Chemotherapy is indicated in the postoperative period of all major thoracic procedures Either penicillin or one of the newer antibiotics may be used as desired Such chemotherapy should be maintained for a minimum of four days and longer if the patient is still febrile.

Where patients have lost considerable blood in the preoperative period and where large amounts of blood have been given as replacement, there is apt to be a rather severe secondary anemia develop during the early postoperative period This should be checked by red blood count determinations or hematocrit readings once or twice weekly or oftener if necessary The reparative process will proceed at a much more rapid rate if the blood and serum protein levels are maintained at near normal states Thus blood transfusions are frequently indicated in the postoperative period to maintain a normal blood level Vitamins are of course necessary for proper nutrition but in the acute injury are not of great importance

Oxygen therapy either by mask or nasal catheter is often advisable in the early postoperative period but only infrequently will it be needed after the first few hours postoperatively In severe crush injuries, blast injuries and hema

tomas throughout the lung oxygen, therapy is indicated until there is evidence of near normal pulmonary function. Post operative complications are almost always a result of not being able to attain one of the two objectives of complete rapid expansion of the lung or maintenance of a clear airway The commonest complication from nonexpansion of the lung is empyema It may of course, occasionally follow even when the lung has been completely expanded but it is much less likely to do so In a report about World War I Yates[1] stated "Resistance of serious activities (*i.e* serosal surfaces) is commensurate with their ability to maintain mesothelial surfaces in approximation" In other words, if the viscera and parietal pleura are able to be in apposition they are much better able to resist infection Empyema when it does develop must be treated just as empyema under any other circumstances When it is seen early it may be cured by repeated thoracentesis and proper chemotherapy but in most instances the organisms will have become somewhat resistant and drainage is indicated.

The common postoperative complications of atelectasis and bronchopneumonia will largely be prevented if attention is paid to proper aspiration of all tracheobronchial secretions Trauma cases, of course are somewhat more frequent victims of postoperative pulmonary complications than elective operative cases inasmuch as they may have had a respiratory infection at the time of their injury It was found in the last war that during the periods of very inclement weather when many of the soldiers suffered from upper respiratory infection, the incidence of postoperative pulmonary complications was proportionately higher

Following severe injury especially in those cases where there has been a marked degree of shock over a prolonged period of time and where massive amounts of blood have had to be given, a certain number will exhibit in the postoperative period oliguria or anuria During World War II this group of cases many of whom proved fatal, elicited a great deal of attention[1] At first it was believed that they were due to mismatching of blood This belief was soon found to be untrue and gradually it was determined that the condition was seen practically only in the very severely wounded and especially those with prolonged periods of very low (blood pressure On examining the kidneys of the fatal cases it was found that the pathological picture was quite similar to that found in so-called transfusion kidneys where there had been mismatching of blood. The lower nephrons were found to be occluded with a material which at first was thought to be hemoglobin It was later found that other pigments were sometimes present and gradually it was evolved that this syndrome could follow any type of severe injury most often in those with prolonged low blood pressures or where there has been severe crushing damage to large muscle groups It has also been described following infections with anaerobic organisms, such as those that cause gas gangrene These lesions with oliguria and anuria are now usually referred to as lower nephron syndrome It is not commonly found in severe chest injuries in the absence of other associated major injuries A certain percentage of the patients who develop this lesion will go on to a restoration of kidney function after a period that usually varies anywhere from seven to fifteen days During the time of oliguria there

borhood of ten per cent, whereas mortality rate when five or more abdominal organs are injured is practically 100 per cent [1]

LATER OPERATIVE PROCEDURES

Although a large variety of complications may appear late in convalescence and necessitate surgical treatment, the majority are manifest within the first few weeks and are related to hemothorax and empyema. The frequency of these developments is a reflection of the efficiency and adequacy of the primary treatment. In a base hospital during World War II Sommer and Mills [5] treated a group of 229 cases of simple hemothorax, fifty seven with clotted hemothorax infected hemothorax in thirty three and empyema in eighty-two The first group of simple hemothoraces probably would not have called for later treatment except under the conditions then existent. These patients were unable to obtain proper management in the early postinjury period Simple hemothorax, of course, necessitates nothing further than aspiration until the pleural space is completely dry and the lung expanded Clotted hemothorax on the other hand presents a different problem as the blood cannot be removed by thoracentesis

The present concept of the management of hemothorax will undoubtedly be modified rather radically during the next few years due to the development of certain enzymes that are now being used In 1949 Tillett and Sherry[37] described the development of a fibrinolysin effect of a material prepared from streptococci There was also a similar related product, the first having the ability to liquefy clotted blood and the second purulent exudates in the pleura. This has now become available and is known as streptokinase and streptodornase. These enzymes, when injected into the pleural space in proper concentration will in a few hours liquefy clotted blood and also purulent exudates so that they can be aspirated readily through a needle Thus, it seems likely that the management of clotted hemothorax will be radically modified in the future. In fact, some of the reports from the Korean action have demonstrated very conclusively the important effects of these enzymes Valle[1] in an experience of 952 patients who had hemothorax found that seventy four per cent of these remained sterile and in sixty-eight per cent the patients were treated by thoracentesis and antibiotics alone and were able to return to full duty In 152 cases decortications were performed. It is still too early to estimate adequately the beneficial effect of the new products, but it is safe to say that they will materially reduce the incidence of decortication for clotted hemothorax or empyema and likewise will be of help in the management of certain postoperative complications when thoracentesis or drainage has not functioned satisfactorily

Decortication Procedures similar to decortication for hemothorax had been described and some modifications of this procedure carried out many years ago But the operation was practically forgotten until it was revived during World War II primarily by Burford [4] Samson [19] Tuttle [27] and others [11] The procedure of decorticating a lung bound down by the membrane that is formed beneath the clotted hemothorax has been amply described in numerous articles in the literature of recent years [29,30] The procedure is most effectively carried out between the fourth and tenth week after injury It is important that the entire

lung be freed completely including the interlobar fissures so that it may expand equally and fill the hemothorax There are those who believe that the parietal pleura should also be removed but there is not much evidence to support that position

It was with considerable trepidation that the first infected hemothorax cases were treated in the same way but it can now be categorically stated that with the protection of the antibiotics one need not be deterred by the presence of infection and there is no doubt but it is the most effective method of management. Simply draining a pleural space that has had a clotted hemothorax for many weeks and has finally become infected is apt to lead to a chronic empyema because the underlying lung is not able to expand, due to the membrane that has been laid down over it. In instances where the patient may be too ill to withstand a major operative procedure preliminary drainage may be carried out and then the thoracotomy done as soon as the patient's general condition improves

Empyema Certain types of empyema not related to hemothorax may also be treated by decortication Burford, Parker and Samson[30] as well as Sanger[31] have advocated this type of treatment. There are no doubt cases in which it is advisable when the lung is held captive by a thickened membrane but for the ordinary case of empyema that is drained within the first two or three weeks the lung will expand nicely without such a major operative procedure

When empyema follows in the post injury period it should be treated exactly as an empyema developing from any other lesion Prompt evacuation of the pleural space is indicated and although this can be done in some instances by thoracentesis, in the majority of cases the results have been disappointing and surgical drainage is by far the preferable procedure Probably the most satisfactory plan is to drain the pleura by the open method. A rib is resected low down preferably the tenth or eleventh, and then all purulent material including the fibrin bodies that can be a cause of difficulty in the postdrainage period are removed by suction or with sponges The pleural space is then flushed out with saline and an airtight closure of the chest wall carried out, leaving a good size drainage tube in place The tube is connected to a water seal bottle or to a source of gentle suction. Such a plan provides airtight drainage for at least two weeks, by which time the lung should be expanded. If air starts to leak around the tube at the end of two weeks it will not cause collapse of the lung

As in other empyemas, attention must be paid to removal of the tube It should not be removed until it has been conclusively demonstrated either by injections of saline or better still of lipiodol with x-ray confirmation that the pleural space has been completely obliterated by expansion of the lung. When this has been achieved the drainage tube can slowly be withdrawn cutting off one or two centimeters each week until the tube is removed

Intrathoracic Foreign Bodies The problem of an intrathoracic foreign body removal has evoked much discussion but it is really not as difficult a subject as the arguments in the literature would lead one to assume [10,16,32] It has been mentioned previously that all accessible foreign bodies should be removed at the time of thoracotomy if there is other reason for opening the thorax. It has also been pointed out that most foreign bodies large enough to demand removal

ences prefers the abdominal route, but the majority of reports have stressed the ease with which the repair can be carried out transthoracically Herniations through the right diaphragm are much more easily repaired from above than below as the large mass of the liver makes exposure of the diaphragm difficult through the abdomen.

Hernia of the Lung· This is an uncommon complication of injury of the chest and most frequently follows traumatic thoracotomies with large defects that could not be satisfactorily repaired at the time of injury According to Maurer and Blades[38] less than 200 cases have been reported When there is evidence of a defect in the chest wall through which the lung herniates on forced expiration it is advisable that the defect be repaired. Various maneuvers have been utilized and the two that have been described by Maurer and Blades have been considered the most satisfactory One is to strip the periosteum of the two adjoining ribs and bring the two layers together over the defect after the intercostal bundles have been mobilized

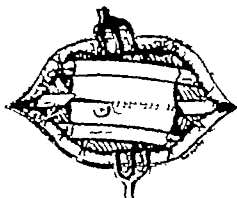


Fig 7 One method of repairing a herniation of the lung through a defect in the chest wall The periosteum has been stripped from two adjacent ribs and is being sewn together This periosteum will form a firm covering at the site of the former hernia.

and sutured as the first line of (Fig 7) In other instances it sible to divide either the rib al below and swing it to the adjac and hold it with sutures placed t drill holes This gives stability chance for the reparative proces continued Other material that used is fascia lata or tantalum m

RESULTS

A discussion of results has co tively little bearing on the outc an individual patient with a thor jury There are so many factor as the time lag from injury to t tation, the general condition of t tient the presence of associated injuries, and the type of the wo self that figures in general hav little meaning It is undoubtedl however that great progress ha made in the intelligent managen thoracic and thoracoabdominal l concomitantly with the develc of thoracic surgery From the available there was a mortality proximately twenty-five per cent chest injuries that were sustained World War I Comparable figu World War II show that the ra been reduced to approximately s cent. Recent reports indicate th results in the Korean theater ar terially surpassing those that we tained in the Second World Wa Statements have been made th mortality rate for all chest injuri now been reduced to approximate per cent. The results from the bas pitals are even better than thos tained in World War II Valle[1] reported an overall mortality rate per cent in a series of 1535 war w of the chest of the reparative type the Korean theater

Under the present circumstances thoracic injuries can be handled rationally and with a high degree of safety when the physiological principles underlying the cardiorespiratory system are understood and respected. With proper replacement therapy procedures of great magnitude can be carried out, when indicated, and under antibiotic protection the factor of infection has been greatly reduced.

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16

Spontaneous Pneumothorax

SPONTANEOUS pneumothorax is a term employed to describe a condition resulting from the accumulation of air within the pleural space without evident trauma This is in contrast to the "artificial pneumothorax" which results from the introduction of air into the pleural space *via* paracentesis either for therapeutic or diagnostic reasons and in contrast to the "traumatic pneumothorax" which is a temporary or a permanent communication forcibly established between the external air and the pleural space Traumatic pneumothorax results from an injury to either the chest wall and/or the lung

An intermediary condition from the point of view of terminology is the rarely occurring infectious pneumothorax where accumulation of air in the pleural space may be traced to gas-producing organisms.

It is to be understood that the accumulation of air in the spontaneous pneumothorax does not develop spontaneously! However the force which produces an open communication between the alveolar bronchial system and the pleural space is not being registered as such by the patient, because it keeps itself as a rule within the "normal" limits of pressure elevation in the intrabronchial and intra-alveolar system Therefore pathological changes are not found in the mechanics of breathing but in the organic conditions of the lung tissue There is one exception namely spontaneous pneumothorax following a coughing paroxysm in children with pertussis In such cases the lung tissue remains essentially unchanged but the force of continuous coughing is so powerful that the expirational pressure may tear the normal alveolar tissues.

Every organic change in lung tissue may lead to a decrease in its mechanical resistance The most frequent intrapulmonary lesions predisposing to spontaneous pneumothorax are

1 Generalized or localized emphysema which may be either congenital or acquired

2 Air cysts of the lung usually existing from birth

3 Tuberculosis, especially when associated with cavitations

4 Neoplastic infiltration.

5 Various etiologic types of abscesses

6 Pneumonia either lobar or bronchopneumonia.

7 Embolic infarction

Tuberculous cavities and abscesses less frequently carcinoma and the pneumonias when ruptured expel not only air but also infectious material into the pleural space This gives an additional diagnostic value The clinical picture is

then that of the accompanying infection (usually putrid) rather than that of a pneumothorax

In all other above mentioned conditions however the clinical course is influenced by the mechanical repercussions of the pneumothorax. The first symptom of escaping air is usually a sharp excruciating pain in the affected side of the chest, followed by strained respiration This pain usually lasts for hours and is relieved only by the administration of morphine The patient may be dyspneic and remain so for a period of time depending upon the extent of the pneumothorax and the degree of the intrapleural pressure To alleviate the dyspnea the patient rests in a sitting position (orthopnea)

The extent of the pneumothorax depends of course upon the amount of accumulated air This may vary from a very small layer of air to a complete collapse of the lung Occasionally the perforation in the lung occurs in an area which is walled off by broad adhesions from the remainder of the chest cavity This results in a "partial" pneumothorax The pressure within the pneumothorax depends upon the physical nature of the lung rupture If it closes immediately on its own accord the pressure reading remains about zero The air is absorbed spontaneously in a short time (about twenty four hours) However this is a rare occurrence As a rule a valve mechanism develops During the expiratory phase (increased by strained respiration) air enters into the pleural space during inspiration the lung tissue is sucked into the injured area thus closing the gap In this way the so-called "tension pneumothorax" develops which by mediastinal and cardiac shift might create an acute and dangerous situation The pressure readings in the tension pneumothorax reach high positive levels

The *diagnosis* of spontaneous pneumothrax can be made without difficulties from the above mentioned signs and symptoms it should, however be confirmed by physical and x ray examination whenever possible Disappearance of vesicular breathing and a tympanitic sound on auscultation readily identify the condition in a total pneumothorax In the presence of pronounced dyspnea tension pneumothorax should be suspected and manometric pressure should be taken. It is difficult to diagnose a tension pneumothorax which has developed in an area which is separated from the remaining pleural space by adhesions Even though auscultation and percussion are unrevealing, a dangerous tension pneumothorax may here develop Direct pressure reading may be hampered by the uncertain location of the pneumothorax X ray studies will then alone provide the necessary information. Adequate x ray pictures not only demonstrate the extent of pneumothorax, but also the degree of intrapleural tension by cardiac and tracheal displacement.

The *therapy* of the spontaneous pneumothorax tries first to relieve the acutely dangerous symptoms caused by high intrapleural pressure The objective is immediate decompression as an emergency measure Decompression is most effectively and rapidly accomplished by removing the air *via* pneumothorax apparatus When no pneumothorax machine is available one may introduce a large hollow needle in the fourth intercostal space of the anterior axillary line As soon as the needle enters the pleural space the compressed air escapes with a hissing sound In this way equilibrium is established between the out

side air and the air within the pleural space while a pneumothorax with a pressure of plus/minus 0 remains Since new air usually enters the pleural space through the lacerated lung it is advisable to leave the needle in place To counteract a valve mechanism the needle may be equipped with a simple device which repeats the action of the valve mechanism of the lung during expiration air must be able to escape through the needle, during inspiration air must be prevented from entering A condom or rubber finger its blind end opened by a cut, is fastened airtight to the protruding end of the needle

A regular drain replaces the needle if it has been ascertained (for twenty to thirty minutes) that air persistently escapes from the ruptured lung tissue A small rubber catheter is introduced under local anesthesia into the pleural cavity at the level of the fifth intercostal space at the midaxillary line and connected with an underwater drainage This procedure usually assures re-expansion of the lung within twenty four hours If expansion is confirmed by x-rays the drainage may be clamped off for a few hours and x ray examination repeated The intercostal drain must only be removed if the pneumothorax does not reoccur After six or seven days the gap in the lung is usually sealed off unless a new "spontaneous" rupture takes place

Immediate and permanent drainage is imperative in cases of ruptured cavities or pulmonary abscesses. A small intercostal drain is then not sufficient to permit continuous drainage of the infectious material A limited rib resection must be performed which permits a large drain to be passed. Underwater drainage is to be added. If the general condition of the patient, the type of tuberculosis and the condition of the contralateral side permit a radical procedure, lobectomy should be considered because of the poor prognosis of conservative treatment in ruptured cavities

Fortunately tension pneumothorax, caused by "spontaneous" ruptures of lung tissue, are infrequent. In the majority of cases only enough air escapes to keep the intrapleural pressure reading around zero But total collapse of the lung necessitates intervention if it proves to be chronic. The term "chronic spontaneous pneumothorax" is being used when after one month, spontaneous resorption of intrapleural air and consequently re-expansion of the lung have not occurred It may however happen that after months or even years a chronic pneumothorax may disappear on its own accord. Formerly relying on this experience conservative treatment was the procedure of choice overlooking the fact that a lung, retracted over a long period of time, never regains its normal function, even though the patient s general condition may not be impaired With this in mind, we have tried (since 1935) more active surgical treatment. In 1944 seven observations so treated, were reported.*

During several thoracoscopies performed on patients with spontaneous pneumothrax, it was observed that the point of rupture could usually be recognized by the presence of subpleural emphysema or so-called "air cysts " As a rule they occurred in the apical region, almost always associated with adhesions which were probably responsible for keeping the rupture open However the results of thoracoscopic division of these adhesions were found to be unsatisfac

*A New Operative Technic for Cysts of the Lung and for Chronic Spontaneous Pneumothorax, J Internat. Coll Surg. 8 421 1945

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Cardiac Wounds and the Left Pulmonary Artery Approach for Pulmonary Embolectomy

CARDIAC WOUNDS

Perforating wounds of the heart due to high speed missiles cause massive hemorrhage into the chest cavity or externally and usually are rapidly fatal On the other hand the prognosis following penetrating stab wounds is more favorable since such wounds often result in cardiac tamponade and blood loss is minimal.

Hemorrhage resulting from penetrating cardiac wounds especially those inflicted by small knives or ice picks tends to be self limited because of the frequent occurrence of cardiac tamponade Tamponade is especially apt to occur when the stab wound is in the so-called bare area, that area in which the pericardium is not covered by pleura. In such wounds blood escapes from the heart more rapidly than from the wound in the chest wall, and the pericardium rapidly becomes distended. This changes the relationship between the pericardium and the anterior chest wall so that the chest wall wound and the pericardial wound no longer are superimposed A check valve action is thus produced, trapping blood in the pericardial sac and preventing large external hemorrhage In this manner death from exsanguination is prevented, but the physiologic alterations resulting from acute cardiac tamponade may in themselves prove lethal. As little as 200 cc of blood in the pericardial sac can produce physiologic disturbances so profound as to be incompatible with life This is in contrast to the situation occurring in chronic pericardial effusions, where stretching of the fibrous pericardium permits the accumulation of large quantities of fluid in the pericardial sac without fatal results

Most patients with cardiac wounds who survive to reach a hospital have cardiac tamponade Occasionally cardiac tamponade and massive hemothorax occur simultaneously and in such cases the presence of the latter may obscure the diagnosis of the former Prompt recognition of the underlying cause of the circulatory collapse in patients with cardiac wounds is essential for proper management. Persistent bleeding obviously requires immediate surgical intervention even in the presence of profound circulatory collapse.

tory since the pneumothorax refilled it self even after this intervention It was decided therefore to resort to open thoracotomy performing an inversion of the emphysematous area by sero-serous sutures The results in all of these cases were surprisingly satisfactory Absorption of the pneumothorax occurred within four to twelve weeks However in those instances where large ruptured air cysts were found we thought it more advisable to plicate the inner wall of the cyst before inversion was done

Later on, most authors reporting on this subject also recommended open repair with excision of the emphysematous lung tissue This procedure in our opinion means unnecessary extension of the operation Likewise we consider it out of proportion to treat large air cysts with lobectomy as it has been frequently suggested and performed. The lung tissue surrounding the area of an excised cyst is fully capable of re expansion.

There are other more active treatment procedures, such as division of adhesions artificial production of pleural exudate to obliterate the pleural space etc These have become obsolete More over they seldom produce satisfactory results

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On the other hand when the circulatory collapse is the result of cardiac compression, certain conservative measures should be employed and surgical exposure of the heart delayed until it can be determined whether or not non surgical measures will suffice

The clinical picture combines the effects of inflow stasis due to tamponade and of decreased cardiac output The striking features are the marked arterial hypotension with narrowed pulse pressure and elevated venous pressure The arterial blood pressure often is unobtainable and peripheral pulses usually are feeble and may be impalpable. The cardiac rate frequently is slow in the early stages but tends to quicken as the tamponade persists The bradycardia is attributed to vagal reflexes originating in the pericardial sac Muffled heart sounds reflect the presence of fluid in the pericardial sac and the decreased cardiac output. The venous pressure usually rises to 200 mm or more of water but excessively high values are not found in acute tamponade The cervical veins notably the external jugulars are full and tense and do not collapse during inspiration Striking distention is not necessarily observed, however since time is required for this change to occur In fair-skinned individuals venous stasis may be evidenced by pallid cyanosis

Associated blood loss makes the picture more difficult to interpret

Cerebral anoxia resulting from decreased cardiac output and cerebral edema secondary to inflow stasis combine to produce restlessness, mental confusion or unconsciousness. The patient's behavior and uncooperative attitude may erroneously be attributed to the effects of alcohol The presence of shock out of proportion to blood loss or to disturbance of pulmonary physiology strongly suggests cardiac tamponade Hypotension due to reflex arteriolar dilatation undoubtedly occurs in some patients with relatively minor thoracic injuries, but all other causes of hypotension should be eliminated before accepting this explanation The presence of an associated pneumothorax or hemothorax may misdirect the attention of the examiner so that tamponade is recognized only after these conditions are corrected

Determination of the venous pressure is important as a confirmatory test and can be carried out with relatively little loss of time if the apparatus is readily available However careful inspection and palpation of the cervical veins usually is sufficient to determine whether or not the venous pressure is elevated. An elevated venous pressure in the presence of arterial hypotension strongly suggests pericardial or mediastinal tamponade

Pericardicentesis is not without danger especially when there is little or no blood in the pericardial sac The importance of careful observation and accurate evaluation of other diagnostic findings therefore is stressed. The correct diagnosis usually can be made by careful physical examination and fluoroscopy

In general, roentgenograms of the chest are of little help in diagnosing cardiac tamponade. The cardiac shadow appears normal or only slightly enlarged and accurate measurements are not possible owing to the short tube to film distance used with patients in the supine position A widened superior vena caval shadow may have significance if rotation is not present. A significantly widened cardiac-pericardial shadow is observed only if sufficient time has

elapsed for pericardial stretching to occur Fluoroscopy usually can be accomplished without serious detriment to the patient and the information obtained often justifies the maneuver In the presence of tamponade the cardiac pulsations appear absent or greatly reduced However some caution should be exercised in the interpretation of this observation since reduced cardiac pulsations are observed in profound shock due to blood loss Also overlying mediastinal hematoma may obscure cardiac pulsation. Finally the pulsations of an acutely dilated heart (as from excessive transfusion or anoxia) may be dampened by the inelastic pericardium

During the past decade there has been a gradual change of attitude toward the management of heart wounds with acute tamponade Formerly most patients with cardiac wounds were rushed to the operating theater for attempted surgical repair The mortality rate varied between twenty five and fifty per cent. With a more conservative attitude toward the treatment of these wounds the mortality rate has fallen precipitously It has been amply demononstrated that pericardicentesis may be used as the definitive treatment in many cases

Upon admission, a patient with a cardiac wound and tamponade is placed in moderate Trendelenburg position oxygen is administered, and a venoclysis is started. At the time of venipuncture a venous pressure determination should be made As soon as blood or plasma is available one of these substances is substituted for the glucose or saline solution. Transfusion is especially urgent if the diagnosis of tamponade cannot be immediately established. Definite improvement in the patient's condition usually follows these measures provided hemorrhage has ceased. The blood pressure may temporarily rise to a level adequate to maintain life This favorable effect is accomplished by further elevation of the venous pressure with increase in the venous return to the heart. More than 1000 cc of blood or plasma probably should not be administered unless there has also been a considerable blood loss

Atropine in large doses *i.e* 0 8 to 1 2 mg (1/75 to 1/50 grain) is usually given especially if bradycardia is present When there is marked bradycardia the atropine is best given intravenously Narcotics are used only in moderate dosage since restlessness usually reflects cerebral anoxia and further depression of the cardiorespiratory centers is to be avoided If the patient's condition is critical and tamponade is evident, fluoroscopic examination need not be undertaken prior to pericardial aspiration

Formerly pericardicentesis was employed chiefly as a temporary measure to improve the condition of the patient en route to the operating room, but the definitive value of this therapeutic procedure has now been established. The prolonged effects of pericardicentesis are due to the fact that the myocardial wound often becomes sealed over during the period of cardiac compression and in many instances remains closed when the pressure is relieved. A second or even a third pericardial aspiration may be justified. However if the tamponade recurs promptly following aspiration, surgery should be resorted to without further delay

Two objections have been voiced against the nonoperative treatment of cardiac wounds with tamponade In some cases partial clotting occurs so that aspiration will be incomplete. Some surgeons have expressed anxiety regard

ing the formation of constrictive pericarditis from the unaspirated blood In general the defibrinating action of the cardiac pulsations tends to prevent permanent clotting and constrictive pericarditis rarely occurs in uncomplicated hemopericardium Experimentally it is almost impossible to produce constrictive pericarditis in the dog with hemopericardium

If pericardial aspiration is unsuccessful because of clotting in the pericardium, pericardiotomy is indicated for relief of tamponade

Pericardicentesis has also been objected to as definitive therapy on the grounds that unless apposition of the wound edges is accomplished by direct suture organization of a thrombus may lead to aneurysmal dilatation The rare occurrence of this complication can hardly justify rejection of so valuable a method of treatment.

Pericardicentesis is most easily and safely accomplished through the left costoxiphoid route The patient should be placed temporarily in modified Fowler's position A short bevel 17 or 18 gauge spinal needle with stylet is quite satisfactory The needle is advanced slowly at an angle of forty five degrees with the plane of the anterior chest wall until the pericardial sac is penetrated After the fascia and ligamentous structures about the xiphoid have been penetrated the stylet is replaced with a small syringe partially filled with saline so that the moment of entry into the pericardial sac can readily be detected If the needle is accurately located it may be left in position temporarily while the surgeon notes whether hemopericardium is recurring.

If pericardicentesis fails because of clotting within the pericardial sac or if tamponade rapidly recurs following aspiration, cardiorrhaphy should be carried out promptly

Cardiorrhaphy: Unless the location of the penetrating chest wound indicates the need for an approach on the right side of the sternum the incision is made over the left thorax anteriorly usually through the fourth or fifth intercostal space General anesthesia administered through an endotracheal tube is preferred The heart can be more rapidly and readily exposed through a transpleural approach and the lateral and posterior portions of the heart more adequately visualized by this means The interspace is split well posteriorly and the costal cartilages above and below the interspace may be divided as necessary for maximum exposure of the heart. Occasionally a portion of the sternum is rongeured away but this rarely is necessary when the transpleural approach is used. A satisfactory exposure must be had before incision of the pericardium since release of intrapericardial pressure may result in profuse hemorrhage

As soon as the pericardium is entered the sac is aspirated dry If active bleeding occurs digital pressure is applied to the myocardial wound while one or two deep stay sutures are passed through the myocardium beneath the finger While hemorrhage is thus temporarily controlled interrupted fine stitches of nonabsorbable suture material are inserted through the myocardium without penetrating the endocardium, after which the stay sutures are removed Effective temporary control of bleeding may also be established by inserting two stay sutures parallel to the finger and crossing the ends Special care must be exercised to avoid occluding coronary vessels and if the myocardial wound is located close to a coronary

vessel mattress sutures should be passed beneath the vessel and through the wound margins

If it becomes necessary to obtain a more adequate exposure of the posterior surface of the heart, the apical traction suture of Beck is employed However too vigorous tugging may cause this suture to pull away Furthermore displacement or rotation of the heart often leads to serious arrhythmias necessitating immediate release of traction In those cases where the heart proves unusually irritable, intravenous pronestyl in 50 to 75 mg doses may be administered to aid in control of such arrhythmias The treatment of cardiac arrest and of ventricular fibrillation is discussed below

After repair of the myocardial wound, all blood clots are removed and the pericardium is closed loosely thus permitting drainage of postoperative pericardial effusion into the pleural space The pleural cavity is effectively drained by closed intercostal tube drainage

CARDIAC ARREST AND VENTRICULAR FIBRILLATION

Etiology and Prevention The recent apparent increase in the incidence of cardiac arrest and ventricular fibrillation may be related to the prevalent use of anesthetics and drugs which produce apnea. If proper precautions were taken to prevent anoxia and hypercapnia in anesthetized patients cardiac arrest and ventricular fibrillation rarely would be encountered. Vagal reflexes originating in areas such as the tracheobronchial tree the hilum of the lung the mesentery and the carotid sinus also are important in their etiology However when the myocardium is well oxygenated, even strong vagal reflexes rarely produce clinically manifest changes in cardiac function Drugs such as atropine and scopolamine, which block these reflexes are of value in their prevention

It is often stated that light stages of anesthesia predispose to sudden cardiac arrest. This is true only when there also is anoxia and hypercapnia to sensitize the myocardium to vagal reflexes, unsuppressed in light anesthesia Deep anesthesia with depression of the medullary centers is far more likely to initiate cardiac arrest than is light anesthesia. Marked reduction in cardiac output from any cause tends to produce myocardial anoxia thereby predisposing to cardiac arrhythmias and arrest.

Cardiac arrest during surgery often referred to as sudden cardiac arrest, is an urgent emergency but usually the

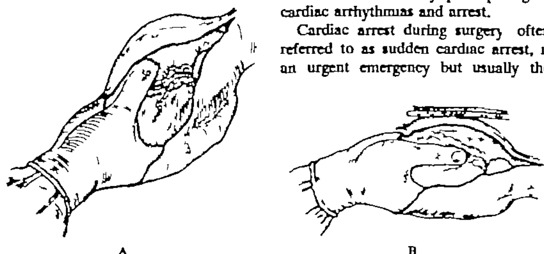


FIG. 1 Technic of manual cardiac compression.

condition does not develop suddenly Almost always it is preceded by a significant period of anoxia and a reduction in the rate and amplitude of cardiac contractions The blood pressure may temporarily be sustained by anoxia and hypercapnia so that the gradual deterioration of the patient is not appreciated.

In summarizing the prophylaxis of cardiac arrest and ventricular fibrillation the following precautions seem most important Adequate pulmonary ventilation, which implies a clear airway the maintenance of effective circulating blood volume and the inhibition of vagal reflexes by the generous use of atropine before and during operation and by direct injection with procaine of the vagus nerves and the hila of the lungs during intrathoracic operations

Treatment During most operations the surgeon must rely heavily on the anesthetist to inform him of the approach or presence of cardiac arrest. However during intrathoracic operations the surgeon should frequently note the heart rate and amplitude of beat and assure himself of the adequacy of ventilation If cardiac arrest appears imminent attention is immediately directed to oxygenation of the patient, atropine is administered intravenously and the vagus nerve is blocked with procaine If these measures fail the injection of 3 to 5 cc of ten per cent calcium chloride directly into the left ventricular chamber usually will improve the tone of the heart and the strength of the beat

When the surgeon or anesthetist suspects cardiac arrest, little time should be lost in confirming the diagnosis or in attempting to initiate myocardial contractions by indirect means No more than three to four minutes of complete circulatory standstill can be tolerated without death or severe cerebral damage The permissible period of delay probably is even shorter when there has been a prolonged period of anoxia prior to arrest. With little attention to the principles of asepsis the surgeon should rapidly enter the thorax through the left fourth or fifth intercostal space anterolaterally In the meantime the anesthetist must insure a generous supply of oxygen by thoroughly ventilating the lungs For this purpose a tight fitting mask may be employed, but usually an endotracheal tube is preferable If cardiac arrest occurs during an upper abdominal operation the pericardium may be entered readily by incising that portion of the diaphragm to which the pericardium is fixed. If fibrillation is discovered the heart may be intermittently compressed until the chest is opened for shock therapy

Inspection of the heart enables the surgeon to make a diagnosis of cardiac arrest or ventricular fibrillation Usually the heart appears atonic and flabby The surgeon immediately institutes intermittent cardiac compression within the pericardial sac at a rate of approximately fifty per minute Occasionally this mechanical stimulation may precipitate ventricular fibrillation, in which case treatment for that condition is continued Compression may be effected with one hand encompassing the heart, with the heart between two hands or with the heart trapped between one hand and the overlying sternum Fig. 1 The optimum method depends somewhat on the size and shape of the heart and on the experience of the surgeon A systolic pressure of 60 to 70 mm of mercury can sometimes be obtained by properly conducted cardiac

compression If the thoracic aorta is clamped the pressure in the aortic arch can be further increased and the circulation to the brain and myocardium augmented. This occlusion should be released intermittently to avoid serious ischemia of the spinal cord and kidneys

One or two minutes may suffice to induce spontaneous cardiac contraction The myocardial tone should be restored before injecting cardiac stimulants If after several minutes of cardiac compression the heart does not resume its beat, 3 to 5 cc. of ten per cent calcium chloride are injected either into the left ventricular or left auricular chamber Cardiac compression is continued so long as the beat is absent or fails to maintain an adequate circulation If after several additional minutes cardiac arrest has not been overcome then 0 3 cc. of 1 1000 adrenalin diluted in five cc. of saline are injected into the left heart. Overdosage with this drug may lead to increased cardiac irritability with subsequent ventricular fibrillation

When cardiac arrest is preceded by severe blood loss cardiac compression cannot produce an effective circulation even if the beat is restored since adequate venous filling does not take place Unless the blood volume is immediately restored, cardiac resuscitation will fail Intra-arterial transfusion may be utilized. Perhaps the most effective means of achieving this is by direct pressure transfusion into the left auricular appendage through a large cannula, so placed that cardiac compression may be carried on simultaneously

If inspection of the heart reveals the muscle fibers contracting asynchronously a presumptive diagnosis of ventricular fibrillation can be made. Since the cardiac output under these circumstances is totally ineffective death or cerebral damage will result within a few minutes Cardiac compression is immediately instituted to improve the tone of the myocardium and provide a maintenance circulation The only consistently reliable method of effecting defibrillation is by the use of electric shock. Currents less than one ampere tend to produce fibrillation For defibrillation a current through the heart of approximately 1.5 amperes is required. For the average human heart 110 volts is needed and for the defibrillation of large hearts some authorities advocate 135 volts or more A series of brief shocks lasting 0 1 second and repeated at intervals of one second are administered through wide electrodes applied to the anterior and posterior surfaces of the heart. More than one series of shocks may be necessary If defibrillation is still not accomplished, the duration of stimulus may be increased to 0.5 second or a higher voltage may be employed. Electric shock causes simultaneous contraction of all muscle fibers with subsequent relaxation, followed usually by complete arrest. Cardiac compression then is employed to restore the beat. If arrest persists after defibrillation, the surgeon must resort to cardiac stimulants as described above Although intracardiac procaine has been advocated by some authorities it probably should not be used in the routine treatment of defibrillation It has been clearly demonstrated that procaine renders restoration of heart beat more difficult after defibrillation However if repeated attempts at defibrillation by electric shock fail, the intracardiac injection of procaine may be tried as a means of raising the threshold of myocardial irritability

THE LEFT PULMONARY ARTERY APPROACH FOR PULMONARY EMBOLECTOMY

Harken and Bigger independently of each other have developed a technic for pulmonary embolectomy through the left pulmonary artery. By this approach it is possible to remove clot from the pulmonary artery or from either of its main divisions without bringing the circulation to a standstill, an extremely important consideration. Another advantage is that the flow of blood assists in removing the clot, whereas when the approach is through the main pulmonary artery or the right ventricle the blood current increases the difficulty of clot extraction.

Operative Technic. An incision is made over the left third rib and cartilage from the sternum to the anterior axillary line and the pectoral muscles are divided. The third cartilage and rib are exposed and resected subperiosteally from the sternum to the midaxilla. The second and fourth cartilages are divided at the sternum and the left chest cavity is entered through the bed of the third rib. With the rib spreading retractor one obtains an excellent exposure of the mediastinal structures. The pericardium is incised perpendicularly in its upper third and the incision is carried to the extreme upper limit of the extension of the pericardium along the pulmonary artery. The incision is continued laterally through the mediastinal pleura along the course of the left pulmonary artery to the lung margin. The left pulmonary artery is rapidly separated from the other hilar structures and heavy catgut or narrow tape is placed around it for traction. Four silk traction sutures are now inserted, two on each side near each end of the proposed incision in the left pulmonary artery. The incision should be made on the anterior surface of the artery starting near the origin of the left pulmonary artery and extending distally for 1.5 to 2 cm. Preliminary to opening the artery a silk purse string is placed around the tip of the left auricular appendage and a large size (8 or 10 gauge) cannula is inserted and is fastened in place by the purse string. Blood is now administered into the auricle* as there is rapid blood loss during the next stage of the procedure.

The incision is now made as outlined by the traction sutures and a large size bent glass drinking tube connected with suction is immediately inserted and is passed into the main pulmonary artery, then into the right pulmonary artery and finally is turned distally into the left pulmonary artery. It is withdrawn after an excursion into each division of the pulmonary artery and if clot is obtained from any segment that segment is again explored. If the clot is at all fragmented parts of it will be extruded through the incision when the tube is withdrawn between exploratory excursions. When no additional clot is obtained a clamp (the ingenious ductus clamp devised by Potts is ideal) is placed across the left pulmonary artery near its origin. Distal occlusion may be achieved by another clamp or by traction on the tape. The incision in the artery is then closed by a continuous everting mattress suture of 0000 or 00000 silk and the obstructing clamps are removed. A few interrupted sutures may be required to control leakage.

A rather large amount of blood is lost during the time necessary for clot removal, but it can be replaced almost as rapidly as it is lost, so is not of too

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*Suggested by Dr William B. Porter (Personal communication)

great importance When sufficient blood has been given into the auricle to bring the pressure to a near normal level the cannula is removed and the opening is closed

The second and fourth cartilages are sutured to the sternum with 32 gauge stainless steel wire and the bed of the third rib is closed by sutures through the pleura and periosteum. One intercostal drainage tube may be placed to be left in for twenty-four to forty-eight hours

JOSEPH P LYNCH, M D

18

Perforation of the Esophagus

PERFORATION of the esophagus although unusual, is an important and frequently dramatic surgical emergency A generation ago such perforations were usually fatal, but the present day status of thoracic surgery and antibiotic therapy leads us to believe that such patients should survive The nature of the esophagus is such that perforation may easily occur and the common causes of perforation are well known The mediastinum is such that perforation into it produces mechanical and inflammatory changes which may rapidly cause the deterioration of the patient unless they are corrected Hence early recognition with exact and adequate selection of treatment is imperative if the patient is to survive

The causes of perforation are many (Table I) and the commonest are those related to instrumentation Many have been recorded following gastroscopy esophagoscopy and endotracheal intubation and even more follow dilatation of the various strictures of the esophagus A large number follow the ingestion of a foreign body or the injudicious or inexpert attempts at removal of a foreign body The remaining causes of perforation are uncommon with the exception of the so-called spontaneous perforation *of the normal esophagus In recent* years, increasing numbers of such cases have been reported, so that one must regard this as a lesion of moderate frequency as well as one of great surgical importance

The effect of an esophageal perforation depends on the condition of the esophagus and mediastinum as well as the location and type of perforation. Sudden perforation of a normal esophagus into a normal mediastinum spontaneously or by a large instrument produces sudden widespread contamination

TABLE I

PERFORATIONS OF THE ESOPHAGUS

A. Intraesophageal
  1 Traumatic
    a. Foreign Body
    b. Instrumentation
      gastroscopy
      esophagoscopy
      endotracheal intubation
      dilatation of esophagus
  2. Disease
    a. Carcinoma of esophagus
    b Ulceration of esophagus
      caustic
      peptic
      other
  3 Spontaneous Perforation of Normal Esophagus *(postemetic rupture)*

B. Extra Esophageal Causes
  1 Traumatic
    a. Stab wound
    b. Gun shot
  2. Disease
    a. Inflammation
      lymphnode
      abscess—tuberculous
    b. Aneurysm

and therefore dramatic symptoms The symptoms are even more marked if vomiting or retching occurs during or after perforation The perforation of some foreign bodies occurs slowly with gradual erosion which allows for partial localization of the mediastinal infectious process and hence slow development of symptoms If the perforation occurs in an area of previous disease in the mediastinum there will be a tendency to limitation of the infection and hence there will be development of local symptoms One exception to this exists in the patients with a perforation of a peptic ulcer of the esophagus Because of mediastinal reaction to the ulceration perforation most frequently occurs directly into the pleural cavity with the production of a hydropneumothorax.

From this brief review it can be seen that the primary pathological process set up by a perforation of the esophagus will vary It may be an acute diffuse mediastinitis or a localized mediastinitis (mediastinal abscess) in both of these, pleural irritation may occur with secondary effusion In some patients, the perforation occurs directly into the pleural cavity establishing a hydropneumothorax, frequently of a tension type

The symptoms depend on the process set up by the perforation *The acute diffuse mediastinitis* usually follows larger perforations of the esophagus into the mediastinum, especially when there is increased pressure in the esophagus as during vomiting or retching Characteristically this is seen after spontaneous perforation of the normal esophagus perforation into a normal mediastinum by instrumentation, and occasionally after perforations following forceful removal of a foreign body or vigorous dilatation of a stricture

Such a perforation produces dramatic symptoms, of which severe pain is outstanding The pain may be localized or diffuse and may resemble the pain due to coronary disease or acute abdominal disease Associated with this is a shock reaction, mild dyspnea and occasionally cyanosis These symptoms, which are usually mechanical or reflex due to the sudden contamination of the mediastinum by air or secretions, frequently improve after the first few hours especially with supportive therapy The physical signs to localize such a mediastinitis may be few in the early hours, although cervical emphysema may occur within a few hours of the time of perforation. This sign whether discovered by roentgenogram or clinically is most



FIG. 1 Illustrates widespread mediastinal emphysema such as occurs in the diffuse mediastinitis following perforation of the esophagus. The air in the mediastinum and neck is clearly visible, and there is beginning effusion at the left base. In this patient, dilatation of a stricture had been performed under general anesthesia. During recovery from anesthesia, the patient vomited and developed the clinical picture as described under diffuse mediastinitis.

characteristic After eight to twelve hours the classical signs of the inflammatory process develop becoming rapidly more widespread and severe

The localized mediastinitis (mediastinal abscess) usually follows erosion of a foreign body perforation of a carcinoma of the esophagus or some type of esophageal instrumentation In fact since the use of antibiotics has become routine following such instrumentation a localized process is much commoner than the diffuse process Again, pain is the outstanding symptom and the pain, although usually localized may radiate anteriorly or posteriorly and is worse on swallowing Dysphagia occurs immediately and is usually severe enough to prevent further attempts at swallowing. There may be localized tenderness and even swelling in the neck in perforation of the upper one third whereas in the lower third, there may be upper abdominal spasm and tenderness The further symptoms are those of any infectious process with chills fever and leukocytosis Usually the abscess remains relatively localized, producing predominately toxic as well as local pressure signs At times the process spreads rapidly developing a widespread mediastinitis producing pressure changes in the mediastinum which result in superior caval syndrome tracheal embarrassment, or sudden death.

Both of the foregoing results of perforation produce pleural effusion by contiguity The degree of effusion will vary from patient to patient, but frequently is severe Therefore the symptoms of the effusion such as dyspnea, cough orthopnea and pleural pain may be great enough to overshadow the mediastinal symptoms and thereby confuse the picture

Hydropneumothorax as a result of direct perforation into the pleural cavity follows perforation of an esophageal ulcer instrumentation directly into the pleural cavity and in a rare patient with spontaneous perforation of the normal esophagus The outstanding symptom is pain, usually related to the side involved. Associated with this is dyspnea which usually increases rapidly since the pneumothorax increases because of the continued leak of air into the pleural cavity Signs of shock are present and soon the signs of an increasing infectious process appear Because of the clinical evidence of a tension pneumothorax, thoracentesis is performed early and the diagnosis of esophageal perforation made by the odor of the air or the nature of fluid aspirated If any doubt exists in this type a swallow of water stained with methylene blue and followed by thoracentesis will confirm the diagnosis

Diagnosis. The diagnosis of perforation of the esophagus is not difficult. A history of previous disease of the esophagus of ingestion of a foreign body or of esophageal instrumentation is an obvious clue Symptoms which indicate mechanical or inflammatory changes in the mediastinum or a pneumothorax in such a patient should lead one to conclude that there has been an esophageal perforation Only patien who have spontaneous perforation (the normal esophagus have no previou indication of esophageal disease However this disease has such a typical history with the onset of the diffuse mediastinitis during vomiting that the diagnosis will certainly be made if the possibility is remembered.

There are few physical signs which directly indicate the diagnosis Obviously cervical emphysema or a devel oping mass in the neck under the above

circumstances, is diagnostic Signs of a developing pleural effusion under the above circumstances should be most suggestive Only too often this has been interpreted as a sign of pulmonary disease and has interfered with making the correct diagnosis



FIG. 2. Illustrates a hydropneumothorax which developed suddenly in a previously well patient. Signs of a tension pneumothorax were present. Thoracentesis revealed intrapleural gastric contents and at operation a perforated peptic ulcer of the lower esophagus was demonstrated.

The most helpful diagnostic signs in the early stages are those found by roentgen ray examination Air may be seen in the mediastinum immediately after perforation if the exposure is correct. When considered with the history such a finding is diagnostic In the clinical picture which develops more slowly the roentgenogram will show a widening of the mediastinum Such a widening may be retrotracheal in location, hence a lateral view of the chest is necessary Associated with such widening, there will usually be visible a developing pleural effusion Since the perforation may be on either side, the x-ray findings may be on either side Only in spontaneous perforation is the lesion on the left side just above the diaphragm in almost every case

The ingestion of radiopaque material in the acute stages has not always been accurate and is seldom necessary In the later stages, a swallow of radiopaque oil may serve to locate a perforation or prove that it is still patent. Occasionally a foreign body may be visible on the roentgenogram and give the necessary clue to the cause for the patient's symptoms

Treatment Prior to the development of the antibiotics the treatment consisted of local drainage of the mediastinum at the earliest possible moment with later feeding by gastrostomy if necessary This routine was successful in patients with a more localized infection When the antibiotics became available the percentage of patients successfully treated by this routine increased, probably because a greater number of patients successfully localized the infection In fact, a certain number of patients have responded to antibiotic therapy alone a welcome, but not to be anticipated, outcome Despite local drainage many patients did not survive and the morbidity and mortality in patients with wide open perforations was excessive Recent developments in thoracic surgery allow for immediate surgical repair of the esophagus following perforation. Thus, the esophagus can be restored to normal, and widespread infection in the mediastinum can be prevented by one operative procedure Therefore, we have available either wide open operation or mediastinal drainage and the correct choice of procedure is usually not difficult

Those patients who develop mediastinal infection slowly so that a well developed abscess is present when the



FIG 3 Shows the cervical esophagus with a foreign body in place left an esophagogram, center one week after removal of the foreign body and right, the foreign body after removal This large sharp fish bone had been present for forty-eight hours before removal, and at esophagoscopy it appeared to be penetrating the wall of the esophagus. Following removal despite vigorous antibiotic therapy the patient had symptoms of a local mediastinal infection without clinical or x-ray signs of an abscess. As indicated in the central picture a small residual periesophageal abscess cavity which had drained into the esophagus, is apparent. There was spontaneous recovery

diagnosis is made should be treated by local drainage Such an abscess usually follows a perforation which is small and closes spontaneously after a short time Therefore a stomach tube for feeding will usually be sufficient

Patients who have diffuse mediastinal involvement, or a hydropneumothorax, should have immediate open surgery Since these occur commonly after perforation by instrumentation or spontaneous perforation of a normal esophagus and can usually be recognized very quickly by knowledge of the perforation or by the characteristic symptoms it is possible to institute such treatment immediately Recent reports leave little doubt that patients with spontaneous perforation should have immediate surgery as the only course which can uniformly produce a successful result. Such patients frequently appear too ill for radical surgery and delay seems advisable However if their poor condition is due to the perforation and mediastinal contamination then surgery is imperative since it alone can restore the patient to normal before irreversible changes occur Obviously all possible supportive aids are used but surgical intervention is not delayed more than a few hours

In every instance of perforation all necessary supportive measures are instituted Pain is relieved shock therapy is instituted respiratory function is assisted antibiotics especially penicillin and streptomycin are started fluids are given as needed and gastric tube suction is used, if possible to prevent regurgitation and further contamination of the mediastinum

At times, the patient's underlying disease (such as an inoperable carcinoma

of the esophagus) or his general condition apart from the perforation is such that open operation for diffuse mediastinitis will be prohibited Then one is forced to make use of large doses of antibiotics, and await localization so that drainage can be performed.

SURGICAL TECHNIC The surgical technics for drainage of the mediastinum are not difficult. The superior mediastinum surrounding the upper one third of the esophagus is approached by a cervical incision. The remainder of the mediastinum which lies below the level of the arch of the aorta is approached by means of a posterior thoracic incision with the partial resection of one or more ribs Occasionally both approaches are necessary to insure adequate drainage. This is apt to be so when a cervical drainage requires later posterior mediastinotomy to supplement it. The exact location for drainage is decided on the basis of clinical signs and x ray examination. The problem of feeding such patients after drainage has already been mentioned. Usually a gastric tube has been sufficient. Gastrostomy has been necessary only when the esophageal perforation is large, requiring prolonged use of the gastric tube or when the patient refuses to tolerate the gastric tube Both operations may be performed under local novocain infiltrative anesthesia, but general anesthesia may rarely be necessary

Cervical mediastinotomy is performed by means of a 6 cm or longer incision along the anterior border of the sternomastoid muscle. The dissection is continued by retracting the muscles and the carotid vessels laterally so that the upper esophagus is exposed. Then by blunt dissection with a finger the mediastinum posteriorly and laterally to the esophagus can be opened. The wound is kept open and the abscess drained by means of a Penrose tube or cigarette type drain Such drainage must be continued until the esophageal perforation is closed hence the drains are removed slowly over a period of ten days so that a well established fistula will result No hard rubber tube drains are used because of the danger of erosion of the moving structures within the neck

Posterior mediastinotomy is performed through a vertical incision at the proper level, as determined by roentgenogram approximately 5 cm from the spine. A segment of the proper rib is removed in the usual fashion. It may sometimes be necessary to remove a portion of two ribs and the intercostal muscle between The pleura is then carefully dissected away from the spine until the mediastinum is entered. On the left side this means that the pleura must also be dissected away from the descending aorta. Care is naturally taken not to enter the pleural cavity Again the wound must be held open until the perforation of the esophagus has closed and the abscess cavity is obliterated. In some locations rubber tubes may be used, but if they are apt to be in contact with pulsating structures then it is preferable to use Penrose tube or cigarette drains

The open operation, as suggested for patients with an acute perforation, is also not difficult Under general anesthesia with an endotracheal tube in place, a conventional posterolateral thoracotomy approach is made through the appropriate intercostal space The pleural fluid, if present, is removed, and the lung is retracted anteriorly The mediastinum, which is usually bulging is opened widely for complete evacuation of all possible pockets of air

or fluid and the perforation in the esophagus is localized and repaired. The technic of repair and the choice of suture material depends on the individual surgeon The author's choice is continuous catgut to the mucosa, and interrupted fine silk to the muscularis The suture line is then covered with a flap of mediastinal pleura held in place by interrupted silk sutures

Drainage of the pleural cavity is provided by a size 24 to 28 French catheter passed through the ninth intercostal space and held to the posterior chest wall by a loose catgut loop The wound is closed in layers after the lung is re expanded. Postoperatively the drainage tube is connected to an under water seal bottle and drainage is continued until the lung is expanded and all fluid has disappeared. Usually this is certain in three to five days Fluids by mouth are given on the third postoperative day and the amount of fluid as well as a diet is gradually increased as the patient can tolerate it. The remainder of the patient's treatment does not differ from that usual in the postoperative course of any patient who has had a major thoracotomy

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19

Emergency Surgery of the Esophagus with Special Reference to Stricture

EMERGENCY surgery of the esophagus is required uncommonly and almost always as a sequel to obstruction, infection, or hemorrhage. The principal causes of obstruction are ingested foreign bodies, strictures resulting from chemical or thermal burns, and new growths. Obstruction developing from the latter cause is of gradual appearance. Only in late or neglected cases does it have emergency implications. Esophageal infection requiring emergency treatment usually has been caused by a foreign body penetrating the esophageal wall with complicating mediastinitis. Rarely varices or a peptic ulcer at the lower end of the esophagus will bleed severely enough to require emergency tamponage or resection.

FOREIGN BODIES

Foreign bodies are of many types, as examination of collections removed from the esophagus by various clinics or operators will demonstrate. In general, they fall into two categories: (1) Objects swallowed by children or the insane, such as coins, pins, toys, and eating utensils. (2) Objects inadvertently swallowed by those of sound mind, either child or adult, and lodged in the esophagus because of the sharpness of one of their surfaces or angles. The majority of such objects prove to be chicken or fish bones, tacks, or pins. Occasionally a large mass of meat gristle becomes impacted just above the cardiac sphincter.

Symptoms. In most instances the symptoms of an impinged foreign body in the upper end of the esophagus are classical and unmistakable. The patient hesitates to swallow and complains of pain each time he does swallow. The pain is located definitely on one side of the neck or the other and corresponds to the side of impingement. Almost without exception the patient can place his finger on the neck exactly where he feels the pain, and almost equally without exception, this localization will subsequently be found to have been a few centimeters higher than the actual level at which the pin or bone end had penetrated the upper esophageal or hypopharnygeal mucosa. Excessive salivation, and drooling of saliva rather than to swallow it, is exhibited by most patients. If pain on swallowing is localized to the neck, one can be fairly sure that the foreign body lies either in the hypopharynx or the upper third of the esophagus above the

aortic arch A complaint of pain or pressure at the suprasternal notch, on swallowing suggests that the foreign body lies in the thoracic esophagus Such cases drool less than those with impingement in the hypopharynx or cervical esophagus but they hesitate to swallow and exhibit signs of pain immediately after swallowing Sharply angulated and pointed foreign bodies rarely reach the lower third of the esophagus before impingement Foreign bodies lodged in this location, usually are large masses of meat gristle large marbles or small wooden blocks The characteristic complaint is that of mid substernal distress sometimes radiating up to the suprasternal notch Drooling is absent but momentarily after swallowing liquids there may be regurgitation into the throat. If a patient with an esophageal foreign body complains of pain on deep breathing, it is an ominous sign that the entire thickness of esophageal wall has been traversed and that mediastinal irritation or infection has begun

Physical Examination By means of a laryngeal mirror with the tongue held forward, one can inspect the pharynx, pyriform sinuses and arytenoids thoroughly Frequently a foreign body suspected of being lodged in the upper end of the esophagus will be found in one of the above mentioned locations instead If salivation is profuse, the use of a suction tip will remove the mucus improve visibility and facilitate this portion of the examination. Foreign bodies lying below the level of the posterior arytenoids, in the hypopharynx or lower can rarely be seen with a mirror and direct instrumentation is required

Fluoroscopic examination is very helpful in the detection of small foreign bodies impinged in the esophageal mucosa such as fish bones especially as sought for in the lateral view Relatively low kilovoltage is desirable in order that the faint shadow of a tiny fish bone may not be "burned out" by excess x ray penetrating power A minor maneuver very helpful in this fluoroscopic examination is that of ballooning the hypopharynx, which is done as follows The patient is made to take a deep inspiration and then to close the lips and hold the nose As expiration is begun he is asked to swallow Air escaping from the trachea thus dilates the hypopharynx producing an air contrast medium into which the shadow of a tiny foreign body can sometimes be seen protruding, and thus accurately localized. In the localization of foreign bodies in the cervical region of the esophagus a swallow of barium more often obscures the lesion than localizes it, and makes more difficult its localization by direct hypopharyngoscopy or esophagoscopy On the other hand an obstruction at the lower end of the esophagus such as by meat gristle, is readily identified by a swallow of barium and the associated filling defect, although it could not be visualized by fluoroscopy without a contrast medium

Metallic foreign bodies, such as coins, tacks and pins of course are identified at once by almost any radiologic technic employed However if one wishes to record, radiographically the location of a tiny thin chicken or fish bone in the cervical esophagus or hypopharynx, special technics may be required One is ballooning of the hypopharynx with air as mentioned above. The other is positioning of the central x ray beam several centimeters above the foreign body itself The central beam

is focused just above the patient's ear for the hypopharyngeal region. Because of the anatomical relationships of the esophagus to the trachea and spine, impacted, nonangulated foreign bodies in the cervical esophagus lie with the greatest diameter placed transversely. For example, coins always lie in this region with a flat surface presenting anteriorly.

Treatment. Promptness, gentleness, dexterity and adequate special equipment are essential to the proper management of a foreign body in the esophagus, if it is to be removed safely and successfully. Edema and infection develop rapidly about a spicule of bone or other foreign body penetrating into the esophageal mucosa and may obscure the intraluminal end of the foreign body. *Unless the greatest gentleness is* exercised, the esophageal wall may be severely damaged. In this connection, full cooperation of the patient is emphasized as essential. Esophagoscopy in children should be done under general anesthesia. If there is any question of the ability of an adult to cooperate, general anesthesia should be used, because one struggling movement of a patient, at an inopportune time during the manipulation of a jagged foreign body, might cause extensive laceration of the esophagus. Frequently foreign bodies can be satisfactorily removed, under topical anesthesia, from the esophagus of an adult. Whether general or topical anesthesia is chosen, adequate preliminary medication should be given, and time permitted for it to become effective, both to allay fear and to reduce buccal and pharyngeal secretion.

Much patience and dexterity often are demanded of the operator for the safe removal from the esophagus of an open safety pin or a jagged piece of bone with multiple bayonet-like points. In no field of surgery are the types and condition of assorted specialized instruments of greater importance. These delicate instruments rapidly become useless *unless scrupulously attended to and* maintained, and the most skillful operator can cancel his effectiveness at a crucial point by failing to have his instruments properly cared for.

Whenever possible, one draws the foreign body into the lumen of the hypopharyngoscope or esophagoscope being used, before extracting it. Sometimes, however, this is impossible, because the foreign body itself is larger than any endoscopic instrument that can be safely used. Coins, for instance, after being *grasped by forceps* passed through the endoscopic instrument, can be drawn against its inner end and safely manipulated out as the instrument is slowly withdrawn. Irregular pieces of bone with sharp angles may have to be cut into portions and removed piecemeal. Tacks and pins can be taken out through the lumen of the endoscopic instrument.

Postoperatively, one should maintain close observation for a period of twenty-four hours, to determine whether any signs of mediastinal infection are developing. If no laceration of the esophageal wall is suspected, the patient can be allowed to take fluids and food within a few hours after recovery from anesthesia. Modern antibiotic and chemotherapeutic agents have greatly reduced danger from the dreaded complication of mediastinitis. The subject of mediastinitis and its therapy are discussed under a separate heading (see Chapter 18).

CHEMICAL AND THERMAL BURNS

Chemical and thermal burns of the esophagus leading to stricture are largely the result of accident or suicidal intent. Included as accidental are the numerous instances of corrosive stricture in childhood following the ingestion of toxic substances obtained from kitchen and pantry shelves Prior to disappearance of the home soap-making industry, lye was the commonest cause Strictures resulting from suicidal intent in swallowing a poisonous substance most often follow the ingestion of acids In fact if one reviews a large series of strictures developing from burns, they can be roughly classified into (a) accidental injuries caused by alkalis (b) intentional injuries caused by acids (c) a small group of strictures the direct result of thermal injury such as inadvertently swallowing boiling tea coffee, or soups.

From whatever causation, strictures tend to occur at one of the four anatomically narrowed regions along the course of the esophagus These are (a) the cricopharyngeus at the upper end, (b) the indentation where the esophagus passes behind the aortic arch in the upper third (c) the point where it is crossed by the left primary bronchus in the middle third and (d) the cardiac sphincter in the lower third

Symptomatology The history usually is an obvious one of swallowing a corrosive substance followed by dysphagia or inability thereafter to swallow solids or sometimes even liquids. If injury has occurred only within the preceding hours, there will be noted extreme dysphagia and occasionally symptoms of shock By the second or third day fever and signs of dehydration probably will be manifest The acute phase of esophagitis lasts from seven to fourteen days and is accompanied by purulent exudate and variable amounts of mucosal and esophageal wall necrosis, following which the process of repair ensues

Treatment If the physician sees such a patient immediately after ingestion of a corrosive substance, massive lavage of the esophagus and stomach should, of course be done at once. Normal saline is as efficacious a solution to use for the lavage as any mechanical cleansing and irrigation being more important than any neutralization effect by mild acid or alkaline solutions that may be employed according to the indications. One will also take appropriate steps to combat shock and to maintain fluid balance

Beyond the initial and systemic therapy the physician's primary responsibility is to maintain an esophageal lumen This can be done most effectively by having the patient swallow a thread immediately Ordinary #30 household sewing thread is a good type to use, and is available everywhere It can be passed easily by fastening the distal end into a #16 lead shot or a small fishhook sinker and then having the thread swallowed By fluoroscopy one can determine whether the lead shot has traversed the esophagus and passed into the stomach Thereafter the thread is swallowed gradually 2.5 cm. (1 inch) or so hourly as it is fed off from a bobbin or spool attached to the patient's shirt or gown The thread will traverse the gastrointestinal tract, and it can be periodically cut off at the anal outlet. Beginning two to three weeks after the injury depending upon its severity and the amount of inflammatory reaction one can begin gradual esophageal dilations over the

guiding thread and under fluoroscopic guidance with minimal risk of perforation of the esophagus and with certainty of maintaining and restoring the esophageal lumen One will start with a small dilator such as #10 French, *and slowly proceed upwards at intervals* of two to three days, until size #45 French is reached. In the later stages, dilations will be spaced at longer intervals of one week and then two weeks, until a #45 French dilator will pass This may require several months The patient can be discharged from the hospital to report back for dilations as an office procedure as soon as the first few dilations have been completed without evidence of systemic reaction.

The commoner sequence of events is that the physician who will be responsible for definitive therapy does not see the patient until weeks or months after the injury The early phases have *passed and fibrous contraction and* strictures have occurred, without measures having been taken to maintain an esophageal lumen Then, the secondary emergency is presented of a patient no longer able to take solid or perhaps even liquid foods Under such circumstances, it is best to do an immediate gastrostomy for feeding which will also be used as soon as the stomach is firmly healed to the anterior abdominal wall, for retrograde bouginage of the esophagus. Oftentimes after a few days of rest, the esophagus which had become completely obstructed, will open sufficiently by virtue of complete rest and subsidence of edema associated with the fibrous stricture, to permit swallowing of a thread This thread is then fished out of the stomach through the gastrostomy opening a string of larger caliber attached and drawn through the esophagus and out the mouth whereupon the distal end emerging from the gastrostomy wound may be tied to the proximal end emerging from the mouth Thereafter bougies are drawn upward through the esophagus periodically and of increasing diameter until an *adequate lumen is restored Retrograde* bouginage is always a safer procedure than peroral bouginage and should be the method chosen for strictures that are late and neglected long and tortuous or multiple Peroral bouginage under fluoroscopic observation and over a guiding thread, is satisfactory when the stricture is single and partial or limited in extent. It is also satisfactory when it can be begun very early after esophageal burn, to prevent development of fibrotic stricture

Occasionally one encounters a case of neglected stricture in which it is impossible to get even a guiding thread swallowed, because of the extent of *stenosis or multiplicity of strictured* areas One can handle the emergency requirement of restoring means for food intake by doing a left upper quadrant gastrostomy and this is the procedure that should be done immediately In addition, one is then prepared to proceed with measures to regain an esophageal lumen. By combined peroral and retrograde esophagoscopy it is frequently possible to thread an ureteral catheter through the strictures to which a thread can then be tied and drawn through. In rare instances of complete stenosis in the middle or upper third of the esophagus the combined procedure of mediastinotomy and esophagoscopy will allow an instrument to be manipulated through an otherwise impassable stricture, so that a thread can be drawn through and dilations subsequently done For such a stricture in the lower third of the esophagus, the alternative

treatment of resection and esophagogastrostomy would be selected Axiomatically one can say that any stricture that can be traversed by a guiding thread can be dilated, given sufficient time and patience It does not necessarily follow that dilation is the preferred method of therapy for all strictures Certain cases in the lower third of the esophagus and certain cases with attending chronic infection and sepsis are best treated by resection and anastomosis

The hazard of perforation or cracking of the esophageal wall is greater in the presence of stricture than in any other condition although it is a constantly present hazard during esophagoscopy or esophageal manipulation for any reason Therefore, we feel strongly that such manipulations should be carried *out under topical rather than general* anesthesia in all instances except for the actual removal of foreign bodies, as previously mentioned The reason is that retention of the pain reflex is one of the best safeguards the patient and surgeon can have against inadvertent false passage

MEDIASTINITIS

If the esophageal wall is cracked or perforated during the course of instrumentation or by foreign body mediastinitis develops very rapidly The symptoms and signs are typical and it is imperative to recognize them immediately Acute sharp pain following a swallow of water pain on inspiration, and pain referred to the shoulder are almost pathognomonic If perforation is suspected the patient should be taken immediately to the x ray department and fluoroscopy done. The presence of pneumothorax or air in the mediastinum is in itself clearcut evidence of perforation By a few hours after leakage and infection, there is broadening of the mediastinum and usually an accumulation of fluid beneath an inferior pulmonary ligament, causing blunting of the corresponding cardiophrenic angle Should there be any doubt the patient should be given a swallow of iodized oil to determine whether there is extravasation Although one s emotional reaction runs counter to giving a swallow of iodized oil, the fact is that it does no damage beyond that already done if perforation has occurred, and it does establish a diagnosis that must be recognized at the earliest possible moment, if perforation exists By prompt mediastinotomy and drainage establishment of gastrostomy for feeding if it has not already been done and massive ad*ministration of antibiotics the compli*cation can be controlled and the patient s life saved Dilations, if the cause be rupture of a stricture, can be resumed within a few weeks

VARICES AND BLEEDING ULCER

We have seen two cases with massive hemorrhage from a vessel in the bed of a peptic ulcer at the lower end of the esophagus which required emergency lower esophageal resection and *esophagogastrostomy for control of* hemorrhage. This is a rare complication of lower esophageal ulcer

No entirely satisfactory method of management for bleeding esophageal varices has even been developed Local *injections with sclerosing agents* ligation of the coronary veins beneath the diaphragm splenorenal and portocaval shunts—all have been used with variable effectiveness occasionally under emergency conditions of hemorrhage a

specially designed double bag tube (Sengstaken tube) is as effective for emergency control of bleeding esophageal varices as any procedure we know The distal bag is inflated within the stomach and drawn upward against the cardia. The proximal bag is inflated within the esophagus to put pressure upon the esophageal walls and compress the veins until thrombosis of the bleeding points can occur This is a temporary expedient only but it does help in control of acute hemorrhage Further discussion of this subject is given in Chapter 28

LEW A HOCHBERG M D

20

Etiology and Treatment of Acute Hiccough

THE symptom known as "hiccup" or "singultus" is the result of an involuntary intermittent inspiratory nonphysiological contraction of the diaphragm (usually involving one side) which is checked abruptly by the reflex closure of the glottis It is accompanied by a characteristic sound emanated from the mouth, protuberance of the epigastrium contraction of the intercostal spaces, and elevation of the thoracic cage The diagnosis of this symptom is made chiefly on the basis of the characteristic sound but is confirmed by palpation of the spastic contraction of the hemidiaphragm on the affected side and observation of the contraction on the fluoroscopic screen.

Hiccup as seen in the surgical patient, may be due to (1) direct or indirect stimulation of the phrenic nerve anywhere along its course or (2) direct stimulation of the diaphragm The efferent pathway to the diaphragm is through the phrenic nerve and the laryngeal branches of the vagus to the glottis The afferent pathway is believed to be through the vagal fibers in the various organs supplied by this nerve and possibly through the phrenic nerve

The causes provoking this symptom are many of which the commonest are the following

(1) *Severe infection* — pneumonia peritonitis acute cholecystitis, severe upper respiratory infection, meningitis and encephalitis

(2) *Toxic and debilitated states*—peritonitis, uremia, ileus, gastrointestinal distention, and a distended urinary bladder

(3) *Psychic disturbances*—hysteria neurosis

(4) *Gastric irritants* — anesthetics, indwelling gastric tubes condiments

(5) *Trauma* — to the abdominal or thoracic viscera and lower bony chest wall

(6) *Mediastinal causes*—irritation or pressure upon the vagus or phrenic nerves as in mediastinitis pericarditis, mediastinal collections and tumors

(7) *Rapid deglutition*—especially in aerophagic persons

(8) *Irritation of the diaphragm*—following injury excessive retraction during surgical operations hemorrhage into the substance of the diaphragm supra and infradiaphragmatic collections, and infections or metastasis to the diaphragm

(9) *Central disturbances* — head injury or tumor cerebral hemorrhage metastasis to the brain or meninges and meningitis.

While it is always sound to advise treating the cause to eliminate the symptom one must also keep in mind the

possibility that in more severe cases the patient may die as a result of exhaustion from the symptom before the cause is identified and controlled Thus it is preferable first to institute such simple measures as will relieve the condition as soon as possible, before resorting to more drastic measures In some cases it may be difficult or well nigh impossible to treat the immediate cause even when recognized early because the patient's general condition prohibits such extensive measures as might be necessary to cope with the existing cause

The patient's condition permitting, he should be propped up in bed and abstain from oral feedings At the same time he should be well sedated—morphine sulfate demerol, and sodium amytal intramuscularly have been helpful in many cases Chloral hydrate, 0.6 Gm. (10 grains) orally, has been reported beneficial in some cases The intravenous administration of 0 1 to 0.2 per cent sodium pentothal, has given relief in more obstinate nontoxic cases. The sublingual administration of scopolamine hydrobromide 0.3 mg (1/200 grain) repeated in a half hour if necessary has been employed with some success in refractory cases. Traction on the tongue spraying the nasal membranes with ten per cent cocaine hydrochloride, and inhalation of the contents of an ampul of amyl nitrite, all have been used with variable degrees of success Spraying ethyl chloride on the shoulder corresponding to the side of the spastic diaphragm as well as the epigastrium has been employed with some success, too Forced deep breathing and the inhalation of seven per cent carbon dioxide or rebreathing exhaled air is an older practice reputed to have some benefit.

While the foregoing measures are being carried out, local conditions such as gastric dilatation, should be relieved by aspiration of the stomach contents and colonic distention should be relieved by means of a Harris drip When hiccup is associated with injuries to the lower part of the chest, the corresponding intercostal nerves should be blocked with procaine hydrochloride.

If the above measures should fail to relieve the patient, the phrenic nerve on the corresponding side should be blocked with procaine hydrochloride If this fails adequately to control the hiccup the nerve should be exposed in the neck and blocked with alcohol When one must resort to this procedure it is advisable to place a loose black silk suture about the nerve before closing the wound so that if the nerve should require secondary exposure for crushing or section, it may be identified more readily

JOSEPH G GILBERT, M.D., AND LAWRENCE A MAZZARELLA M D

21

Neonatal Emergencies

EMERGENCY TREATMENT OF NEONATAL ASPHYXIA AND LARYNGOTRACHEITIS (CROUP)

IN discussing the emergency treatment of severe nondiphtheritic croup or "laryngotracheitis" it is necessary to consider the disease briefly Despite recent advances in antibiotic therapy severe infectious nondiphtheritic croup as we know it, remains a cause for considerable morbidity and mortality among children

Acute laryngotracheitis is an infection of the respiratory tract occurring most frequently under three years of age and characterized usually by primary inflammation of the pharynx with subsequent involvement of the larynx, trachea, and bronchi A tenacious, thick mucopurulent exudate helps produce variable respiratory obstruction with severe symptoms of toxicity The condition may however be primary in the larynx or in the subglottic area. Occasionally it follows the aspiration of a foreign body The disease is more prevalent among infants and young children although adults are not immune to it. Direct smears from the upper respiratory tract reveal a mixed infection of streptococci, staphylococci pneumococci micrococci catarrhalis and hemolyticus influenza B It has been suggested that a filterable virus may play a part in preparing the ground for invaders

Many classifications of croup have been proposed Since the term croup covers a symptom-complex rather than a single clinical entity a suitable classification should serve as a guide not only for diagnosis but also if possible, for prognosis and treatment The classification used at our contagious disease hospital has been based on pathological changes encountered in the treatment of the disease Accepting this pathological classification seems to dispel some of the confusion caused by referring to nondiphtheritic infectious croup by such overlapping terms as pseudomembranous croup fibrinous croup acute laryngotracheitis, acute fulminating laryngotracheobronchitis H influenzal type B croup virus croup false croup membranous croup and spasmodic croup

The *first class* in our classification is acute catarrhal laryngotracheitis The *second class* is supraglottic edematous obstructive laryngitis The *third class* is divided into two subgroups (A) Subglottic exudative (inspissated) obstructive laryngotracheitis and (B) subglottic edematous obstructive laryngotracheitis The *fourth class* is acute obstructive laryngotracheobronchitis

Other classifications have been based on infectious etiologic agents However the sequelae of hypoxia that follows the local pathological changes have proved of more clinical importance than the general toxic effects caused by the infectious agents Particularly so since the advent of antibiotic therapy there has been a marked decline (in the past few years) in the general mortality of croup and in the number of cases requiring surgical intervention While a large part of the decline in mortality and severity is the result of better diagnosis and improved surgical technic for relief of hypoxia, credit must also be given to the effect of antibiotics.

The respective classes will now be taken under consideration.

Acute Catarrhal Laryngotracheitis. This is the commonest and most benign form of infectious croup These patients have a brassy cough, hoarseness, and mild suprasternal and infrasternal retractions Although laryngoscopy is not necessary it may be performed if doubt exists as to diagnosis The larynx appears red, velvety and a mucoid secretion may be seen on the vocal cords There is a minimal amount of edema of the subglottic structures and the vocal cords move freely at all times These patients usually respond well to increased humidification of the air and proper temperature This is especially effective because they as a rule, become ill in rooms that are overheated and low in humidity Antibiotics shorten the course of acute catarrhal laryngotracheitis and probably often prevent progression to the more serious type of croup Prognosis here is and was always good

Subglottic Obstructive Laryngotracheitis: This is a more serious condition. It occurs most frequently in children under three years of age It may be of the inspissated, exudative or edematous type

Subglottic exudative or inspissated obstructive laryngotracheitis is accompanied by marked suprasternal infra sternal, and intercostal retractions hoarseness cough (croupy) marked toxicity and prostration Symptoms are frightening enough to require immediate laryngoscopy Laryngeal examination reveals a narrowed airway or chink with dry crusts green gray or black in color The cords are almost immobile Following aspiration of the exudate and removal of the crusts by forceps the cords will be seen to move again and the tracheal mucosa will show very little edema. The respiratory difficulty will be eased immediately Treatment should then be employed to prevent further drying of the respiratory mucosa by the use of humidification Very often no further instrumentation is necessary and the final results are gratifying.

In *subglottic edematous obstructive laryngotracheitis* the picture is similar There is encountered marked stridor tachypnea, pallor exhaustion and occasional cyanosis Laryngoscopy will reveal a narrowing of the airway by a subglottic edema frequently involving the thyroarytenoid joint and preventing normal excursions of the cords This condition demands the establishment of an airway A straight Mosher life saving tube, or similar tube, is first passed through the chink into the trachea and then a low classical tracheotomy is performed Since the complete substitution of tracheotomy for intubation, the mortality in these instances has dropped considerably Although some of the improvement is due to the use of antibiotics, immediate relief from the existing hypoxia exerts the most

sels are particularly vulnerable and with their rupture one is more apt to get pneumomediastinum

Violent struggling during tracheotomy will increase the likelihood of developing interstitial pulmonary emphysema, pneumothorax, and pneumomediastinum During surgery the bulging dome of the parietal pleura (or Sibson's fascia) may be nicked or torn giving rise to pneumothorax. With an airway *in situ* while a tracheotomy is being performed, a child is more apt to be quiet and these injuries precluded.

Summary: Any infection of the larynx in children is characterized by difficult and noisy respiration, and brassy cough.

The attending physician should bear in mind that every child with acute laryngeal obstruction is potentially a victim of acute obstructive laryngotracheobronchitis until proven otherwise Too often, this frequently fatal disease is diagnosed as laryngismus stridulous or catarrhal laryngitis and only when the child is near death, does the gravity of the condition become apparent. These patients should be hospitalized, a laryngoscopy performed, and the pathology evaluated.

The amount of airway the amount of inspissated exudate, pseudomembrane, and edema will determine whether operative relief for the obstruction is necessary If so even before the dyspnea becomes urgent, a tracheotomy should be performed only after the introduction of an airway or bronchoscope.

The question of what operative procedure to use depends upon the findings on direct visualization. Where there is no adequate airway because of edema, supraglottic or subglottic, tracheotomy is the treatment of choice If after aspiration of inspissated exudate an adequate airway has been reestablished, there remains only a moderate edema and good mobility of the cords, humidification, antibiotics, and close observation are the treatment of choice

When the condition is a diffuse process involving the entire tracheal and bronchial mucosa, with much tenacious and gummy material throughout, bronchoscopy and aspiration are first tried. It is then left to the judgment of the bronchoscopist whether this procedure should be supplemented by tracheotomy If following the initial aspiration, relief of symptoms is marked, one can postpone tracheotomy and give medical therapy a chance If symptoms recur rebronchoscopy should be done If the edema and the immobility of the cords have increased, tracheotomy should be performed.

Postoperative treatment is very important. Difficulty in maintaining an adequate airway even after tracheotomy commonly results from reaccumulated exudate Therefore, subsequent aspirations are necessary through the tracheotomy tube and sometimes through the tracheotomy incised with the tube removed from the trachea. The use of an oxygen tent with proper humidity makes the postoperative course smoother in the more severe cases of croup Adequate nursing care is always necessary in the treatment of severe croup cases.

The prognosis in most cases of croup which are properly classified and properly treated, is good.

ATELECTASIS OF THE NEWBORN

Atelectasis of the newborn is one of the fearful conditions necessitating emer

gency treatment, and involves the obste trician, pediatrician, anesthetist and endoscopist It may be defined as an incomplete expansion of the lung, partial or complete The word is derived from the Greek words *ateles* meaning incomplete and *ektasis* meaning expansion

It has been definitely established that various degrees of atelectasis are present in the lungs of the newborn. The lungs expand progressively during the first few days of life Therefore we note how well the above definition suits the subject under consideration Aeration of only a portion of the infant's lung is necessary for complete oxygenation of the blood Physiological atelectasis although present in many cases, rarely causes concern and usually escapes notice since it is consistent with normal development and well-being

Experiments have proven that the air pressure necessary to expand the lungs of the stillborn infant is ten times that which adults use in quiet respiration Relatively much more pressure is required to aerate the alveoli for the first time This resistance is due to the first stage of development with existing partial atelectasis and to the cohesion of the moist surfaces of the collapsed air passages

Wilson and Faber feel that lack of expansion in premature infants is not failure of respiratory effort in many instances though this is weak but is due to the cohesion of the collapsed alveolar surfaces which is enhanced by disturbances of the respiratory center imperfectly developed thoracic wall, or the obstruction of the airway by aspiration of amniotic fluid, mucus or blood There is strong evidence in support of the theory that the human fetal respiratory tract is subject to rhythmic respiratory movements during which there is a tidal flow of amniotic fluid through the bronchial tree and alveoli Examination of lung secretions of stillborn infants show some amniotic fluid present

It follows therefore, that there is a certain amount of aspiration *in utero* Where immaturity of the lungs exists, as in premature births where the aspiration of amniotic fluid or secretion has taken place and where, because of difficult labor the normal reflexes are weakened, it becomes obvious that progressive aeration is not possible and that there will exist a condition of increasing atelectasis The association of prematurity in extensive atelectasis is impressive

When we think of embarrassment of respiration in the newborn, we have in mind the clinical picture of atelectasis In such instances a newborn infant has appreciable suprasternal infrasternal, and intercostal retractions, and in spite of conservative measures of aspiration the administration of oxygen, and resuscitation the infant shows a stridor listlessness and pallor followed later perhaps by cyanosis In this case it becomes evident that aeration is not taking place normally Not infrequently suction of the hypopharynx by a small rubber catheter inserted through the nostrils will suffice in removing excessive fluid mucus, or blood in the upper respiratory tract and stimulation of the pharynx may be sufficient for the newborn to expel further larger amounts of secretion by coughing, gasping, or crying. Normal respiration will then ensue

In the above instance although there may have been some atelectasis our method of stirring up and stimulating the respiratory system was enough to initiate normal breathing. In the former in spite

of conservative measures, normal respiration could not be initiated Conditions which bring about this difficulty are to be considered and investigated in order that proper treatment might be carried out.

When we speak of immaturity of the lungs we mean incomplete formation of the alveoli so that they cannot expand and aerate with normal stimuli It is this situation which is most frequently met with in neonatal asphyxia

A careful history should be obtained, including type of delivery anesthesia amount of asphyxia type of cry and any difficulty in swallowing in order to uncover the etiologic factor Protracted, difficult labor with instrumentation may cause serious central nervous system injury with respiratory embarrassment. Where this injury to the respiratory center exists there may be periods of apnea. In this period there is listlessness irregular breathing, and gasping. Early there may be evidence of spasticity of the extremities, and later flaccidity supervenes

Physical examination of the lungs thoracic cage and upper respiratory tract should be complete and roentgenograms ordered if necessary Cardiovascular and congenital anomalies such as double aortic arch, bronchoesophageal fistula, and esophageal stenosis may cause secondary atelectasis because of overflow of esophageal fluid or by extra tracheal or bronchial pressure Difficulties encountered with swallowing and feeding should direct attention to the possibility of such anomalies Lipiodol studies may be needed to confirm them Exhaustive studies may be necessary in evaluating causes for neonatal asphyxia so that proper treatment can be administered.

In the final analysis, where there is no appreciable response to such conservative measures as catheter aspiration, artificial respiration, and resuscitation, and where the diagnosis of secondary atelectasis has been established, direct visualization and bronchoscopic aspiration thus become imperative

An infant (newborn) laryngoscope is used to expose the laryngeal structures By this procedure any abnormalities of the hypopharynx and upper respiratory tract could be discovered and dealt with. If there is definite atresia of the larynx caused by webbing or improper formation of the vocal cords or condromatous masses or tumefactions in the larynx present tracheotomy should be considered. If the laryngeal structures are normal, a 3 mm x 25 cm bronchoscope is then inserted. The trachea, carina, and main stem bronchi are then examined These areas are relieved of any obstructing exudate by suction so that proper aeration may take place This procedure is expeditiously carried out with no anesthesia and very little trauma, and very often, with much gratification

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Management of Acute Cardiac Arrhythmias During Anesthesia

ANESTHETICS and surgical manipulations may affect the heart in one of three ways (1) By interfering with the pacemaker and the conduction mechanism thereby causing disturbances in rhythm (2) by directly depressing and impairing the efficiency of the myocardium usually reversible or even irreversible changes are initiated which cause a reduction in output and (3) by impairing the efficiency of the peripheral circulatory system. An increased demand for work and a decrease in return of blood to the heart results Obviously combinations of any or all three of these situations may exist. Although a variety of derangements of the circulatory system may be associated with surgery the appearance of arrhythmias often arouses more concern than any other symptom of circulatory distress Even the slightest alteration in rhythm frequently causes the surgical team to become alarmed and pause or to institute therapy Many clinicians lose sight of the fact that serious derangements of the cardiovascular system may exist without any irregularity of rhythm Arrhythmias even though serious are not the only important cardiovascular disturbances that must be considered. On the other hand, some clinicians go to the other extreme and tend to disregard them entirely This attitude obviously is not based upon sound judgment.

As soon as an arrhythmia is detected one must determine its exact nature and its causes in order to institute rational therapy Some arrhythmias are of little or no significance They are transient and often disappear without treatment. Others are severe and, if allowed to persist, may seriously hamper the work of the heart or become aggravated and terminate in disaster Most arrhythmias are readily detected and diagnosed by palpation alone, others by palpation and auscultation However many cannot be detected or correctly diagnosed without an electrocardiograph. The immediate availability of an electrocardiograph is highly desirable in the event of a cardiac emergency It is almost a necessity in the operating room if any volume of cardiac or thoracic surgery is performed Except in emergency situations its routine use during general surgery is not only unnecessary but costly and impractical. The direct writing types of apparatus are being used more and more because they are easily operated These are more suitable for use during surgery

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as they permit moment to moment recordings and visualization of the electrical activity of the heart. The finer graduations of electrical changes however are not always accurately recorded. In these instances the string type of apparatus is desirable. The oscilloscope types of apparatus permit visualization of the curves but are not always equipped with devices for making permanent records. In most cases if the rhythm is regular by palpation and auscultation one may assume that a normal rhythm is present. It must be remembered, though, that arrhythmias may exist which cannot be detected by these means. For instance an A V nodal rhythm may be present which escapes detection because the pulse is usually perfectly regular.

Etiological Factors. Five possible etiological factors must be considered when abnormal cardiac rhythm appears during anesthesia and surgery. As one would expect, the first, and most important, of these is pre-existing cardiac disease. The arrhythmia may have been present at some time preoperatively and disappeared with rest or treatment but reappeared when the patient was subjected to the effects of surgery or anesthesia. More frequently though the arrhythmia is present immediately before surgery and persists and may even become aggravated during the operation. These derangements appear to be the most difficult to overcome. The anesthetist and surgeon would do well to consult with the cardiologist, who is familiar with and has cared for the patient preoperatively regarding the therapy to be instituted. The second factor to be considered is the effect upon the heart of anesthetic and other drugs used as adjuncts to anesthesia. All anesthetic drugs in one way or another if administered in sufficient quantity exert some influence upon the heart. The medical literature is replete with studies of the effects of anesthetic drugs upon this organ. Unfortunately much of the data has been obtained from observation in animals or in heart-lung preparations. It is questionable how much of the information obtained from such studies is applicable to man. Data on the effects of anesthetic drugs upon the diseased human heart are meager. One can only surmise what the effects might be on the diseased organ from knowledge of the effects on a normal heart. Anesthetic drugs may affect the heart in one of two ways: (1) They may depress the myocardium and reduce cardiac output by impairing efficiency and (2) they may influence the conducting mechanisms reflexly or directly and increase or decrease the irritability and thereby cause disturbances in rhythm. It is possible for both effects to coexist. Chloroform and ethyl chloride cause notable cardiac disturbances. A third factor which must be considered when arrhythmias appear is the possibility of reflex stimulation of some structure remote from the heart. Stimulation of the vagus anywhere along its course or traction on the lung and other intrathoracic structures or abdominal viscera may cause disturbances in rhythm. These will be discussed in more detail later. The fourth factor to be considered is the affect of manipulation or stimulation of the heart itself. This of course occurs during thoracic or cardiac surgery or during mediastinal explorations. Incisions of the pericardium and myocardium or stimulation or manipulation of the auricles and ventricles during operation may initiate arrhythmias. A fifth factor and one which has been given little or no consideration in the

past but whose importance is becoming more and more recognized is the influence of the chemical composition of the blood Reduced oxygen tension a high or low carbon dioxide tension increases in blood *p*H hyperkalemia, hypokalemia, hypocalcemia may all occur during anesthesia and surgery and disturb cardiac rhythm Any one of these five factors singly or combined may precipitate arrhythmias in normal or diseased hearts The appearance of a heretofore not present arrhythmia usually indicates that a cardiac emergency exists which demands a diagnosis as promptly as possible and institution of immediate treatment.

Types of Arrhythmias: Classification, diagnosis, and differentiation of the various types of arrhythmias are beyond the scope of this discussion A brief resume of the types one might encounter is in order at this point, however They can be classed as follows [1] (1) Affections due to abnormal impulse formation. Included under this heading are (a) extra systoles—ventricular nodal, or auricular (b) auricular flutter and fibrillation (c) paroxysmal tachycardia—auricular nodal, or ventricular (d) ventricular fibrillation (2) Affections due to impaired conduction (a) in the stem of the bundle—delayed, partial, or a complete block (b) bundle branch block (c) intraventricular block. (3) Affections due to vagal influences, (a) sinus arrhythmia (b) sinus bradycardia (c) sinoauricular block (d) auriculoventricular block. Asystole though not an arrhythmia, is considered along with the arrhythmias.

Therapeutic Agents Various therapeutic agents and methods are available for management of arrhythmias [2,3] They may be classed as follows (1) Those which affect the vagus. These either stimulate or depress the parasympathetic division of the autonomic nervous system Vagal stimulants frequently used are mecholyl and neostigmine The vagus or structures communicating with the vagus may be stimulated, as for example the carotid sinus These measures are used to treat auricular tachycardia. Vagal depressants include anticholinergic drugs such as banthine atropine scopolamine and hyoscyamine It is stated that complete block of the vagus may only be accomplished by use of 6 mg. (1/10 grain) of atropine intravenously Clinically much smaller doses have been found repeatedly to be effective although larger doses may be necessary to inhibit secretions (usually 0 8 mg. [1/75 grain]) (2) Those which increase conduction Epinephrine stimulates the heart by a direct effect on the myocardium and conduction tissues The drug speeds auriculoventricular conduction, decreases the rate of A V block resulting from disease or vagal stimulation and excites the idioventricular pacemaker in patients with complete heart block. It may induce ventricular premature beats and the more serious types of ventricular arrhythmias Neosynephrine ephedrine and other sympathomimetic drugs are used for their cardiac acceleration effects. (3) Drugs which decrease cardiac irritability Procaine and procaine amide are used to overcome various types of ventricular arrhythmias The depressant effects protect the heart against increase in irritability induced by epinephrine and cyclopropane Quinidine acts in a similar manner Papaverine is a myocardial depressant also but it is of questionable value. (4) Sympatholytic substances dibenamine, priscol, ergotamine yohimbine are ganglion-blocking agents which nullify

the action of epinephrine as well as ephedrine which has been mentioned above (5) Myocardial stimulants—digitalis and its alkaloids These are largely used in the treatment of cardiac failure and the management of auricular fibrillation and auricular flutter Barium chloride (2 cc of two per cent aqueous solution) may be used to stimulate an atonic heart in cardiac resuscitation when asystole has occurred.

The drugs most frequently used during surgery when arrhythmias develop are procaine, procaine amide, atropine or quinidine Epinephrine ephedrine and barium and calcium chloride are used for cardiac resuscitation. A "cardiac emergency" tray containing these drugs and syringes for parenteral administration if immediately available may be instrumental in saving many precious moments in time of emergency

Arrhythmias Due to Heart Disease. In the first group in which the arrhythmias are due to cardiac disease, the most frequently encountered and most distressing are (a) those due to cardiac disease associated with thyrotoxicosis In thyrotoxicosis the heart appears to have increased "irritability" Excitement, apprehension anoxia, carbon dioxide excess and stimulation from intubation and surgical manipulation increase and cause arrhythmias to appear or aggravate those which are present preoperatively The pulse may be regular when the patient comes to surgery but as the operation proceeds and manipulations of the gland occur the arrhythmia appears Prophylaxis along the lines of proper preparation is better than a cure If a patient is not properly prepared with a sedative and is excited and apprehensive a tachycardia develops and the blood pressure rises Later more severe irregularities may develop

Exactly what the procedure should be once the arrhythmia appears cannot be stated empirically Premature beats and auricular fibrillation are the most frequently encountered arrhythmias If they make their appearance early and elimination of technical difficulties such as poor airway deep anesthesia and carbon dioxide excess does not cause them to disappear postponement of the operation may be advisable If the operation has been in progress some time then, termination at some suitable point is advised. One must not overlook the fact that often after removal of the gland arrhythmias cease Sudden death on the operating table is more frequently encountered in this type of heart disease than any other The management of these patients has been greatly simplified since the introduction of the derivatives of thiouracil

(b) Patients with heart disease on an arteriosclerotic basis comprise the largest group of cardiac patients encountered requiring surgery Ventricular or auricular premature beats auricular fibrillation and various degrees of heart block are the most frequent arrhythmias noted As anesthesia is induced and surgery proceeds, they tend to become more frequent and increased in severity The best course to follow in this type of patient is to defer surgery until the patient is prepared properly with digitalis quinidine or pronestyl Some thoracic surgeons prefer to administer quinidine (0.2 Gm —3 grains—orally) prophylactically three or four times the day prior to operation to offset auricular fibrillation or other arrhythmias in patients whose cardiac status is questionable or who are known to have heart disease [4] Patients with hypertensive

cardiac disease are managed similarly to those who have arteriosclerosis or coronary artery disease

(c) Next in importance are patients with rheumatic heart disease The majority of these patients have long standing heart disease, having acquired it in childhood or early youth. Auricular fibrillation appears to be the com monest arrhythmia in this class of pa tient followed next by premature beats of auricular or ventricular origin

Acute rheumatic fever is seen occa sionally in surgical patients In these, a delay in conduction time or heart failure may be present. Here again the treatment is purely individual Quinidine or digitalis whichever is deemed better may be used although in certain instances the operation may proceed without using any form of therapy As a general rule arrhythmias are not a problem in patients with congenital heart disease. When present, once again, their management is purely individual.

In syphilitic heart disease character ized by aortic insufficiency arrhythmias are uncommon The main concern with this type of lesion is coronary insufficiency and sudden death from ventricu lar fibrillation or asystole

Patients having toxic myocarditis from fever of "toxic states," such as diphtheria pneumonia, or typhoid fever are occasionally subjected to operation. In these disturbances in rhythm are not as worrisome as impending cardiac failure due to reduction in cardiac efficiency

The sudden development of cardiac irregularity not ascribable to the usual causes during surgery may indicate that coronary occlusion has occurred. The manifestations of coronary occlusion dif fer little from those noted in unanesthetized subjects Hypotension and car diac failure with pulmonary edema may suddenly develop In others auricular fibrillation or flutter or the tachycardias may appear Despite the large number of patients whom one would expect to be candidates for sudden onset or aggravation of heart disease, this complication is very infrequent on the operat ing table

Arrhythmias Due to Anesthetic Drugs. Drugs used for preanesthetic medication may influence cardiac rhythm.[5] Atropine stimulates the central nervous system initially and causes a transient slowing of the pulse from di rect stimulation of the vagus center The writer has seen this bradycardia mistaken for heart block As the anti cholinergic effect becomes established, the pulse quickens. In certain individuals notably infants and children a sinus tachycardia may be noted due to the atropine Scopolamine does not appear to cause either response unless larger than usual doses are administered. Hyoscyamine (bellafoline) behaves like atropine Morphine on occasions causes a slowing of the pulse most probably from central stimulation of the vagus center although removal of cortical influences by sedation may also be a factor Barbiturates have no remarkable effect upon cardiac rhythm in the usual doses when employed for premedication

The halogenated hydrocarbons (nota bly chloroform, ethyl chloride, trichloroethylene) and cyclopropane exert their efforts either reflexly or directly upon the heart, which results in arrhythmias Since cyclopropane is the most widely used of these drugs the arrhythmias resulting during its administration are of most interest. Spontaneous arrhythmias of various types appear during cyclo-

propane anesthesia • It is well recognized that abnormal rhythms arise from displacements of the pacemaker Ventricular tachycardia of multifocal origin and even ventricular fibrillation are possibilities with this drug These severe arrhythmias are rare indeed Most frequently one observes merely a bradycardia believed to be largely of vagal origin Morphine because of its vagal effect may enhance this bradycardia. At times this bradycardia is indistinguishable from the more serious but less frequently observed A V nodal rhythm Arrhythmias are most frequent in deeper phases of cyclopropane anesthesia They are also enhanced by anoxia They tend to disappear as anesthesia is lightened and as the airway is improved Epinephrine and the closely allied sympathomimetic amines cause serious arrhythmias when administered simultaneously with this drug Ventricular tachycardia and even ventricular fibrillation are strong possibilities if these amines are used during cyclopropane anesthesia. Presumably the heart is reflexly sensitized by the cyclopropane In animal experiments it has been observed that receptors located in the mesentery are stimulated by the drug Impulses then pass by afferent fibers through the celiac plexus along sympathetic pathways to centers in the diencephalon Efferent impulses then pass from these centers over the cardiac nerves to the heart.• Procaine procaine amide yohimbine and ergotamine nullify the action of epinephrine and protect either by their sympatholytic action or direct cardiac depressant action against arrhythmias caused by the combination Ether administered concomitantly in four per cent concentration also affords protection Oenethyl vasoxyl, ephedrine and pituitrin do not sensitize the heart to the same extent as epinephrine and do not cause this type of arrhythmia It is however advisable to avoid the combination of cyclopropane and pressor amines The use of vasopressors is permissible as soon as the patient has recovered from anesthesia In ordinary depths of anesthesia cyclopropane does not appreciably disturb cardiac output and arrhythmias do not as a rule appear From the foregoing discussion the rationale for avoiding the use of cyclopropane when cardiac irritability or cardiac disease exists is obvious It is advisable to avoid the combination of digitalis and cyclopropane The effects of the drug upon the heart are purely functional No irreversible changes are known to occur when the drug is removed.

Chloroform, though little used in the United States also deserves some mention because in some respects it behaves like cyclopropane It exerts a dual action upon the heart ₐ,ₛ In the presence of high concentrations a depression of the myocardium occurs and cardiac output is reduced. When administered to excess, asystole develops. Arrhythmias of various types occur both during light and deep anesthesia Bradycardia and auricular and ventricular premature beats may occur from vagal effects when inhalation is commenced. It is presumed that these are possibly the result of stimulation of the respiratory passages by the drug. They are enhanced by epinephrine and prevented by atropine Shifts of the pacemaker occur in deeper stages of chloroform anesthesia and ectopic foci in the ventricles give rise to irregularities Epinephrine in combination with chloroform is as lethal as it is with cyclopropane Ventricular fibrillation

may result when the combination is used. Its appearance is inhibited or prevented by procaine intravenously

Ethyl chloride is similar to chloroform in its behavior[9] Vagal stimulation occurs initially[5] Bradycardia and various manifestations of block or ventricular premature beats or tachycardia may occur Atropine likewise inhibits or prevents their appearance Ventricular fibrillation may occur as a terminal event or if used with epinephrine By far the commonest cause of death with this drug, however is due to myocardial depression which results in asystole or ventricular fibrillation and which is caused by overdosage

Arrhythmias may occur during trichloroethylene anesthesia These are similar in most respects to those noted under chloroform anesthesia

Although arrhythmias are possible and do occur under ether anesthesia, they are uncommon As a matter of fact, when derangements of the heart do exist, ether is the drug of choice for major surgery because it appears to be the least innocuous When caused by ether arrhythmias are usually supraventricular in origin[10] They are characterized by a delay in conduction or a shift of focus for impulse formation Sensitization to epinephrine does occur but not to the degree noted with chloroform or cyclopropane Ethylene and nitrous oxide anesthesia without anoxia, alone or in combination with ether are likewise characterized by infrequent disturbances in rhythm Sensitization to epinephrine likewise does not occur Also there is no sensitization when basal narcosis is employed with the ultrashort acting barbiturates, such as thiopental, thiosecobarbital, evipal, or tribromethanol (avertin) Arrhythmia resulting from direct effects of spinal, peridural, and various types of nerve blocks are also infrequent. None occurs during local infiltration or topical anesthesia with various local anesthetic drugs The muscle relaxants such as curare tubocurarine syncurine or flaxedil, do not cause arrhythmias

Drugs used as adjuncts to anesthesia frequently cause arrhythmias *per se* or in combination with the anesthetics The vasoconstrictors have been discussed and, of course are notorious for this For this reason their use during inhalation anesthesia is not advised Epinephrine alone, or in combination with anesthetics increases cardiac irritability Toxic doses may cause ventricular fibrillation During local and spinal anesthesia vasoconstrictors are used to overcome hypotensive states Certain of these vasopressors cause derangement of conduction Bradycardia is not uncommon following their use This may be caused in one of two ways Both the peripheral resistance and cardiac output are increased. A reflex slowing of the heart mediated by cardiac sinus stimulation occurs. A sinus bradycardia results Neosynephrine behaves in this manner Others such as vasoxyl cause a vagal stimulation. This often persists after the vasopressor action has disappeared. Pituitrin and pitressin are vasoconstrictors The action is obtained by stimulation of smooth muscle. They have no effect upon the heart sensitized to chloroform or cyclopropane. Any cardiac effects observed are due to the ischemia caused by constriction of the coronaries which the drugs may cause. The question is often asked, "May pitressin be used with cyclopropane?" What should really be asked is, "May pitressin be used?" The effect is no different with cyclopropane than with ether or other drugs Usually nothing happens,

but coronary constriction is a possibility to be borne in mind

Arrhythmias Due to Direct Effect on the Heart Direct stimulation of the heart itself causes arrhythmias [11 12] Obviously these occur during intrathoracic operation when the mediastinal structures are manipulated or when the heart is incised or manipulated in any manner The ensuing disturbances under these circumstances vary with the frequency and intensity of the stimuli and the state of the heart. Instrumentation of the heart drying of the pericardium, the use of packs around the heart, or retractors to gain exposure during the intrathoracic operations are some stimuli which precipitate arrhythmias The writer is familiar with one instance in which hot saline solution caused asystole Intrinsic disease of the heart, blood chemical changes due to anoxia, carbon dioxide excess, or variation in electrolyte concentration may further lower the threshold to such stimuli. Generally the noxious effects of such stimuli are heralded by extrasystoles If stimulation persists the more serious type of irregularities often referred to as "prefibrillation states" appear These are characterized by ventricular tachycardia delayed auriculoventricular conduction or auriculoventricular block. Unless measures are instituted to decrease the irritability of the heart the development of ventricular fibrillation is a strong possibility The prefibrillation rhythms cease spontaneously with removal of the stimulus. If they persist, the use of 20 to 30 cc (⅔ to 1 ounce) of one per cent procaine hydrochloride intravenously is indicated [13] The application of one per cent procaine to the pericardium may be of benefit also Some workers prefer to use a continuous intravenous drip of 0 1 to 0.2 per cent procaine prophylactically administered at the rate of 1 Gm (15 grains) per hour throughout the procedure [14] Others prefer to use procaine amide If this drug is employed it is administered intravenously in a dose of 100 to 500 mg. (1½ to 7½ grains) No more than 200 mg. (3 grains) per minute should be injected. Quinidine may also be used

Reflex Effects. There are numerous reports in the medical literature concerning reflex effects upon the heart of stimuli originating at some site removed from the heart. These effects are largely transmitted along afferent parasympathetic pathways to some central point, usually the medullary centers The efferent portion of the reflex are in the vagus [10] The nerves implicated are those belonging to the parasympathetic division of the autonomic nervous system usually the vagus or tenth cranial the ninth or glossopharyngeal, and the pelvic nerves Structures innervated by the vagus nerves are believed to give rise to the majority of reflexes Inasmuch as the vagus has a wide distribution throughout the body there are many structures which may be stimulated during surgery and anesthesia which could give rise to these reflexes which are considered so important by some that they have been named "vago vagal reflexes" One cannot deny that reflex stimulation mediated along the vagus nerves can and does exert adverse effects upon the rhythm of the heart and other cardiovascular physiology however it is often overemphasized without basis of fact Asystole or ventricular fibrillation due to technical mismanagement of anesthesia such as improper use of drugs or inadequate airway have been ascribed to vagal stimulation with insufficient evidence in support of the contention and often in the face of

sufficient evidence that something else was the cause Nonetheless it is well recognized that stimulation resulting from direct laryngoscopy intratracheal intubation, bronchoscopy esophagoscopy manipulations of the trachea traction on the hilum of the lungs manipulation of the pleura or diaphragm, rib stimulation pericardial manipulation, pleural incision intercostal nerve stimulation and, in short manipulations of any of the intrathoracic structures cause arrhythmias. Bradycardia, nodal rhythm, ventricular extrasystoles delayed A V conduction and auricular extrasystoles are some of the irregularities noted In rarer instances ventricular tachycardia and fibrillation or cardiac standstill have been reported In the experience of the writer situations under his surveillance with such end-results were associated with either a combination of anoxia, CO_2 excess, or sudden changes in blood volume, combined with stimulation of structures having vagal innervation. Associated with the arrhythmias of vagal origin often are hypotension and respiratory disturbances, such as laryngeal spasm coughing or apnea. It is often said that the portion of the vagus in the upper thorax is more susceptible to stimulation associated with such reflex changes than that of the lower This does not always hold true, however because the writer has on numerous occasions noted severe disturbances in rhythm caused by stimulation of the plexus at the lower portion of the esophagus. Manipulation of the abdominal viscera and traction on the mesentery of the kidney spleen, and gallbladder have also been reported to cause disturbances in cardiac rhythm. These are not as frequent as those encountered in intrathoracic manipulations. Serious arrhythmias and even ventricular fibrillation and cardiac asystole have been reported during tonsillectomy and other oral pharyngeal surgery These structures are innervated by the vagus and glossopharyngeal nerves Carotid sinus stimulation is often incriminated as the cause of serious cardiac arrhythmias syncope and even fibrillation and asystole in operations about the neck The intimate association of the sinus with the glossopharyngeal and vagus nerves suggests this as a possibility Blocking the vagus either systemically by means of anticholinergic drugs such as atropine, hyoscyamine, scopolamine, or banthine, or locally by injecting both vagi at the jugular foramen with procaine [17] or by local infiltration of the operative site to block the vagal nerve endings abolishes these disturbances The hilum of the lung, the laryngeal and bronchial mucosa, and the periesophageal plexus are areas in which the reflexes are most easily elicited Traction and manipulation of the phrenic nerves, particularly as they approach the diaphragm, have been noted to cause arrhythmias. Stimulation or traction of the pelvic structures and viscera may also induce reflex changes, as may manipulations about the perineum, rectum, and genitalia. Presumably the sacral component of the parasympathetic division of the autonomic nervous system is concerned in this type of reflex.

Embolic phenomena particularly pulmonary emboli cause arrhythmias. Indeed, the irregularities and the circulatory collapse induced by massive pulmonary emboli are believed to be due to reflex effects. They may be difficult to differentiate from electrocardiographic changes caused by cardiac infarction.

Metabolic Effects: Changes in the

chemical composition of the blood markedly influence cardiac rhythm Anoxia, particularly when it accompanies anesthesia with many of the anesthetic drugs in current use influences cardiac rhythm markedly Acute anoxia initially causes a tachycardia associated with hypertension As the oxygen tension falls a bradycardia ensues presumably of vagal origin Further depletion of oxygen causes depression of the heart muscle Asystole is the terminal event rather than ventricular fibrillation, although either may occur Anticholinergic drugs the barbiturates and morphine may prevent the bradycardia due to vagal stimulation but not that due to myocardial depression. A slow pulse in the presence of anoxia may be an ominous sign and indicate that asystole is imminent. In milder degrees of anoxia irregularities in rhythm appear but are not so severe The amplitude of the T wave is reduced or the T wave may become flattened out Any arrhythmia occurring when anoxia is present should be looked upon with considerable disdain

Retention of carbon dioxide with a resulting respiratory acidosis is not uncommon during anesthesia, particularly during thoracic surgery Abnormal tensions of carbon dioxide may cause disturbances in rhythm [10] The junctional tissues are affected by a carbon dioxide excess in the blood As a rule auriculoventricular conduction is depressed An increase in tone of the cardioinhibitory center and depression of activity in the sinoauricular node occurs. At a pH of 7 0 a complete heart block results Some experimental evidence exists that cardiac arrest may be more easily precipitated in the presence of a respiratory acidosis if the heart is subjected directly or reflexly to noxious stimuli Whether or not this is the case in man remains to be demonstrated. Nevertheless the wisdom of correcting any acidosis whether it is metabolic or respiratory in origin before anesthesia is induced or surgery is commenced cannot be questioned. A decrease in blood carbon dioxide tension sufficient to shift the pH above 7 35 causes an increase in rate of conduction of the auriculoventricular tissue The rate of impulse initiation is increased and the tone of the cardioinhibitory center is lowered In asphyxia the combined effects of carbon dioxide excess and anoxia are present.

An increase or decrease of blood electrolytes particularly potassium may cause derangements of the heart beat. As a rule these can be detected only electrocardiographically Potassium depletion is not a frequent occurrence in surgical patients but is a possibility which must be borne in mind, especially when there has been considerable loss of fluid from the stomach or small intestine [9] When the plasma potassium falls below 3 0 m Eq (12 mg per 100 cc) changes in the electrocardiogram are observed Lowered T waves, depressed ST segment and prolonged QT interval may be noted Potassium salts parenterally are indicated during anesthesia and surgery The maximum amount of potassium salts considered safe to inject intravenously is 3 to 4 mg. per kg. of body weight Potassium chloride is the easiest to use because it does not affect the pH Usually solutions containing 1 to 3 Gm per liter are given no faster than 8 to 12 cc per minute Excess potassium may occur after vigorous therapy following potassium deficiency and gives rise to disturbances in rhythm The cardiotoxic effects of potassium give rise to eleva

tion of the T wave and disappearance of the P The ST segment is depressed and the QRST complex spreads Cardiac arrest with the heart stopping in diastole may result when the potassium rises to ten to eleven milliequivalents per liter (40 mg per 100 cc.) Glucose and insulin and, if the kidneys are normal, normal saline may be used to relieve hyperkalemia.

Certain hormones, particularly those arising from the adrenal and thyroid gland have been incriminated as being the cause of arrhythmias[8,9] Epinephrine liberated endogenously during induction of anesthesia from excitement or apprehension when drugs which increase cardiac irritability such as chloroform, ethyl chloride, or cyclopropane, are used, has been held accountable for sudden death during induction of anesthesia Although these are presumed to be due to ventricular fibrillation there is no factual basis for the contention that endogenous epinephrine may cause sudden death in man during light anesthesia. Ventricular fibrillation has been known to occur in animals, particularly cats, as a result of the liberation of endogenous epinephrine when chloroform or cyclopropane are used, but in the dog this does not appear to hold true. In dogs for example priscoline, which is a sympatholytic agent, did not protect the heart from overdosage of ethyl chloride nor prevent arrhythmias when stimulation occurred It is the writer's impression that fatalities when reported in man are more probably due to overdosage of the anesthetic drug or other technical difficulties rather than fibrillation due to the liberation of endogenous epinephrine

During thyroidectomy clinicians have suggested that an adrenergic substance is liberated from manipulation of the gland This forms the basis for the use of sympatholytic agents or high spinal anesthesia during thyroidectomy Here again the statement is based on conjecture rather than fact. During manipulations of the adrenal gland, arrhythmias may occur During removal of pheochromocytoma the adrenal hormones are liberated in excess Cyclopropane is contraindicated and blocking agents such as priscoline are advised when this lesion is present Arrhythmias due to excess of adrenal hormones are not uncommon in this condition When adrenal cortical extract is administered during anesthesia arrhythmias often arise, most probably due to the incomplete removal of epinephrine from the preparation.

Management of Arrhythmias During Operation With the exceptions of the arrhythmias due to intrinsic cardiac disease or to direct manipulations of the heart itself the irregularities encountered during surgery and anesthesia pose no problem which cannot be corrected if promptly recognized. Undue emphasis has been placed upon arrhythmias caused by anesthetic drugs The majority of difficulties concerning the heart arising during anesthesia are largely due to anoxia, carbon dioxide excess, overdosage of anesthetics, or a combination of these factors Most arrhythmias disappear when anesthesia is lightened, when the airway is improved or when noxious stimuli cease. When the irregularity is due to the effects of the anesthetic upon cardiac tissue and these simple measures are not effective the drug should be abandoned and the use of another drug is indicated. Arrhythmias due to vagal hyperactivity are controlled by the use of anticholinergic substances, notably atropine or scopolamine. The writer feels that the use of

blocking agents such as procaine, procaine amide[10] and the recently added ganglionic blocking agents such as dibenamine priscoline banthine and others advocated to prevent or minimize arrhythmias due to anesthetic drugs such as cyclopropane, is not justified These substances are not in themselves innocuous Besides, their introduction into medicine has been so recent that their pharmacologic behavior and studies on their toxicity are not complete The use of a drug which possesses one inherent set of dangers or objectionable features to make another drug, which has its own set of dangers and objections usable does not appear rational particularly when the action of neither is well understood Ether still remains a good and useful and safe anesthetic The routine use of procaine or procaine amide intravenously for thoracic surgery is likewise not justified The writer finds such therapy needless and superfluous in the majority of cases When the simple expedients aforementioned fail and arrhythmias are uncontrollable and one has no choice but to continue with the anesthetic drug or the manipulation causing them, then and only then is their use justified

A good deal of nonsense is written today concerning cardiac resuscitation The medical profession at large as well as the lay public has been deluded into the belief that some new and remarkable advance has been made in medicine Obviously this is not the case It is only that physicians have at last awakened and are attempting to save patients who were allowed to die because of surgeons temerity The profession is acquiring more audacity and is promptly opening the chest to massage and defibrillate the heart. Rather than congratulate each other and publicize the results of a successful resuscitation of a heart, which should never have been allowed to fail, this energy should be directed at prevention of cardiac arrest The majority of cardiac arrests are preventable particularly in those instances in which the heart responds promptly to treatment

In a strict sense the term "cardiac arrest" means cessation of activity of the heart. There are many causes of cardiac arrest Unfortunately lack of space does not permit a discussion of the etiological factors. The diagnosis is made when no pulse is felt or heart sounds heard in the presence of respiratory failures If the abdomen is open the absence of pulsation of the aorta or iliac vessels confirms the suspicion immediately The electrocardiogram may be misleading because some activity may be manifest even when no effective beats are occurring. Cardiac resuscitation must be instituted without delay to be successful Many attempts at cardiac resuscitations are successful so far as restoring the rhythm and activity of the heart to normal is concerned, but the patient ultimately dies after a period of time because the circulation is interrupted for too long a period and tissue damage results Even though the heart is restored to full activity the patient dies as the result of ensuing tissue anoxia. If the subject survives cerebral damage renders him a human wreck with serious neurological sequelae and impaired mental processes The technic of cardiac resuscitation is described elsewhere in this volume

There seems to be some discussion as to whether or not epinephrine should be used during cardiac massage In general, the wisest procedure is to omit it and first attempt massage without it be

cause it increases myocardial irritability and may precipitate ventricular fibrillation. Where it is used it should be injected into the right auricle rather than the ventricle Some feel it should be combined with 5 cc. of two per cent procaine to prevent fibrillation.

Ventricular fibrillation is a more serious state than asystole and more difficult to overcome [18] Defibrillation must precede massage Physical stimuli, cold or electricity are necessary A heart cannot be defibrillated by massage alone or by drug therapy Procaine, contrary to the general belief does not reverse ventricular fibrillation In order to cope with this situation one must have a defibrillator The defibrillator suggested by Wiggers is a device which utilizes the ordinary 110 volt electric 60 cycle alternating current. The instrument consists of a voltmeter an ammeter and a variable resistance which reduces the current to 1 or 1½ amperes and two electrodes An elaborate expensive apparatus is not necessary As a matter of fact, one can be made at home, the design is so simple The current is delivered to the electrodes which must be cup shaped and circular about 7.5 cm. (3 inches) in diameter These are to be applied to as much of the heart as possible A make and break button delivers the current for 0 10 seconds The current is applied to the heart at two-second intervals. Usually three to seven shocks suffice Before the shocks are applied the heart is massaged for a period of thirty seconds in order to expel the blood from its chambers, because it is almost invariably dilated due to stasis from the venous blood which continued to return for a short time when ventricular fibrillation has occurred After defibrillation, it usually is necessary to resume massage until the heart is allowed to reestablish its own rhythm Ice cold saline may be applied in the event a defibrillator is not available There are reports of successful defibrillation performed by applying the exposed ends of two wires carrying ordinary house current directly on the heart. The direct application of procaine to the surface or the intracardiac injection of 150 mg of procaine to reduce cardiac irritability is justified if defibrillation cannot be achieved promptly

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SAMUEL LEVINE, M D

23

Roentgen Films of the Abdomen as an Aid in the Management of Acute Surgical Conditions

THE diagnosis of intra-abdominal surgical conditions may be baffling not only to the internist but to the surgeon as well Clinical signs and physical findings are sometimes ill defined or absent, thus making a definite decision difficult in a questionable surgical abdomen. Considerable aid may be obtained from survey films or so-called flat plates of the abdomen. A minimum of three films should be taken a high and a low supine film and an upright film In cases in which the patient s condition permits films in the prone and lateral decubitus positions are advantageous It is important to stress that in approaching the interpretation of the so-called scout films one should be familiar with the clinical history of the patient on the other hand a preformed, prejudiced clinical impression may lead to misinterpretation of films and faulty conclusions Impartiality is of supreme importance in handling the clinicoroentgenologic problem at hand.

When a perforated viscus is suspected an upright film is most informative Free air beneath the right leaflet of the diaphragm is pathognomonic of a ruptured viscus The amount of air may be considerable or minimal depending upon the size of the perforation and the rate of escape of gas The greater the interval of time between the onset of symptoms and the roentgenologic examination the greater the likelihood of positive findings and the larger the accumulation of air (Fig. 1) When the



FIG. 1 Ruptured duodenal ulcer Free air beneath diaphragm simulating magenblasen.

differential diagnosis lies between a perforated peptic ulcer and a ruptured appendix, in the presence of a spreading peritonitis, one cannot say with any degree of finality whether it is one or the other simply because there is free subdiaphragmatic air since ruptured appendices and ruptured intestinal diverticula may also yield the same findings. It is fair to say however that ruptured peptic ulcers are much more often the etiological factor of free intraperitoneal air One should emphasize the fact that when a patient is roentgenographed shortly after the onset of symptoms no free air may be seen, and the surgeon should be guided by clinical findings as to the handling of the case If fluoroscopy is negative an upright roentgenogram should be taken since minimal collection of air may be seen on the film and missed on fluoroscopy When the air collects beneath the left diaphragm it may be confused with the magen blassen to obviate this, a left decubitus film should be taken. Small crescent shaped collections of air beneath the left hemidiaphragm in juxtaposition to the magenblassen must not be overlooked as these readily make the diagnosis of a ruptured viscus most likely a perforated ulcer Lateral decubitus films with the patient lying on the left or right side are of utmost importance, since free air may be observed in the flank with this change in the patient s position (Fig 2)

In obscure cases with abdominal symptoms in which coronary thrombosis must be differentiated as the underlying cause of the abdominal findings an upright survey film is of great aid to the attending surgeon and is very often life saving (Fig. 3) Therapeutic pneumoperitoneum administered occasionally in tuberculous patients will confuse the issue when a surgical problem presents itself After laparotomy free intraperitoneal air will persist for about ten days and should be discounted in any given case. In hepatocolic interposition a condition in which a loop of colon lies immediately subjacent to the right dia



Fig 2. Peritonitis due to perforated jejunum Note fluid levels in erect position.



Fig. 3 Early peritonitis. Ruptured appendix.

phragm one should be extremely careful in the interpretation of the upright film The presence of haustral markings will aid in differentiating this condition from free subdiaphragmatic air

The diagnosis of intestinal obstruction is often made or corroborated by a survey x ray film Intestinal obstruction is attended with the accumulation of variably large amounts of fluid and gas The three chief sources of gas in the bowel are swallowed air chemical and bacterial putrefaction and diffusion of gas from the blood stream The experiments of McIver in 1926 dealing with the ligation of the pylorus in dogs with peritonitis established absence of gas in the intestinal tract. Hibbard estimates about seventy-two per cent of the gas in obstruction of the small intestines to be derived from swallowed air The experimental work of Wangensteen and Rea, consisting of a cervical esophagostomy with exteriorization of the esophagus followed by production of an obstruction in the ileum, showed collapsed small bowel on postmortem examination. This preclusion of swallowed air prevented accumulation of gas in experimentally produced obstructed bowel. Incidentally these dogs survived for thirty-five to fifty-seven days on parenteral fluid A controlled group of dogs with similar obstruction lived only five days indicating the lethal effects of large amounts of gas in intestinal obstruction. Sperling has established that, locally acute distention of the bowel causes contraction of the longitudinal muscle and an increase in weight. In iliac obstruction there is a reversal of the normal gradient of weight per foot of the small bowel, so that the loops immediately proximal to the obstruction are much heavier than the loops of jejunum or duodenum. The edematous, fluid filled loops of ileum sink to the pelvis in the erect examination Wangensteen has determined that there is a marked delay in water absorption from obstructed loops Whereas normally eighty-seven per cent of the water instilled into a loop is absorbed in one hour only nine per cent is absorbed in an obstructed loop (Figs 4 & 5)

Ochsner and Wangensteen have shown that there is fluid and gas re-



FIG. 4 Peritonitis. Ruptured appendix.



FIG. 5 Peritonitis due to ruptured sigmoid diverticulum Note prominent mucosal folds in jejunum.

tention two to four hours after ligation of the gut. One can demonstrate roentgenologically intestinal obstruction six hours after initial onset. When one considers the fact that approximately 8000 cc. of saliva gastric juice bile succus entericus and pancreatic secretions are normally poured into the small bowel daily it becomes readily apparent why ample fluid is accumulated in the gut rather early following an obstruction In older obstruction cases there is a predominance of gas in the affected loops In small intestinal obstruction the loops assume a stepladder appearance, are dilated, and very often present a hair pin turn. If there is marked small intestinal dilatation the involvement is most likely jejunal since more secretory activity occurs in the jejunum than in the ileum The more proximal the intestinal obstruction, the greater the degree of intestinal dilatation. It is usually abnormal to find gas within the small bowel so that a *priori* when clinical signs of obstruction are present, this finding should be regarded with suspicion Trapped gas in one isolated loop of small bowel may be the earliest manifestation of obstruction and one is cautioned not to delay treatment until all the diagnostic criteria are present, for that may spell disaster to the patient. The presence of a fluid level in the upright film is an additional valuable sign of obstruction however considerable difficulty may be experienced in obtaining satisfactory upright films in ill patients Gas in intestinal obstruction may be due to ingestion, diffusion through the bowel wall and putrefaction Ingested air may traverse the small bowel in six to fifteen minutes.

It is often rather hard to distinguish between small-intestinal and large intestinal loops and a posteroanterior film may be very helpful. The small-intestinal loops are diffusely located throughout the abdomen whereas the colon has more of a peripheral distribution. Haustrations when definitely identified indicate colonic involvement, but one must be careful not to confuse these with pseudohaustrations seen in dilated small-intestinal loops

It is exceedingly important not to overlook the fact that in strangulated obstructions there may be a minimum amount of intraenteric gas accompanied by considerable fluid Erect and lateral decubitus films are important to avoid pitfalls in diagnosis in these desperately ill people Strangulated loops may appear as circumscribed soft tissue masses producing extrinsic pressure upon the bladder and may thus simulate twisted ovarian cysts or mesenteric cysts (Fig. 6)



FIG. 6. Ovarian cyst displacing stomach upward.

Distinction between intestinal obstruction and paralytic ileus may be made by the varying levels of the fluid in a given loop of bowel. In simple intestinal ob-

struction the height of the fluid columns in the afferent and efferent limbs of a loop vary in height from time to time in the course of repeated fluoroscopic and radiographic examinations In paralytic ileus with no peristalsis the fluid levels tend to remain uniform Frimann Dahl emphasized the pronounced diminution of diaphragmatic excursion in adynamic ileus

Basal atelectasis is likewise more prone to appear in adynamic ileus and peritonitis In the latter there is a tendency for the fluid levels in the pelvis to remain fixed whereas the levels are changeable in the presence of peristalsis Intraperitoneal exudate may be assumed to be present if the small bowel walls are thickened and jagged in appearance A full rectum may be confusing in evaluating pelvic fluid

The presence of gas in both the small and large bowel bespeaks either an obstruction that has released itself or a partial obstruction. A similar appearance may be produced by morphinization. Morphine affects the duodenum greatly the duodenum is first constricted and then dilated In susceptible individuals one repeatedly observes accumulation of gas in both the large and the small bowel. To discount the effect of postoperative morphinization the drug should be withdrawn and the patient again roentgenographed for any change in the intestinal gas pattern Ordinarily the ileocecal valve blocks the egress of gas from the small into the large bowel In sigmoidal obstruction of long standing there may be regurgitation of air into the cecum with marked distention or even rupture of the cecum Tremendous dilatation of the cecum on survey films should arouse the suspicion of a low colonic obstruction If a subdiaphragmatic abscess is suspected it is imperative to make upright, supine, and prone films with the Bucky diaphragm and also lateral decubitus films In a well defined abscess there is a fluid level seen only in the upright position A lateral view is necessary for more precise localization to aid the surgeon in the proper surgical approach to the lesion Upon fluoroscopic examination if elevation of the diaphragm and restricted excursion combined with pleural effusion or basal pneumonitis are seen, it is cause for increased suspicion Subhepatic abscess may be suspected when there is a dense shadow confluent with the lower border of the right lobe of the liver displacing the stomach and duodenum to the left, and the hepatic flexure downward

Perinephric abscess may be suspected when there is obliteration of the ileopsoas line a scoliosis of the lumbar column away from the affected side, an indistinct kidney image and a restriction in the upright posture of normal kidney mobility Often there is a "belly



FIG. 7 Retroperitoneal neuroblastoma. Note widened iliopsoas shadow

ing" of the psoas mass and this finding should not be ignored but reported (Fig 7)

A pelvic abscess may offer diagnostic criteria by the presence of a homogeneous opacity in the region of the pelvis coupled with an upper abdominal ileus Depending upon the size of the abscess upward degrees of displacement of loops of bowel are observed. Roentgenologically pelvic abscess must be differentiated from ovarian uterine and retroperitoneal tumors The latter are usually more sharply defined and circumscribed than in pelvic inflammatory disease An ovarian dermoid reveals itself through the presence of calcifications teeth and fluid levels of varying densities (Figs 8 9 & 10)



FIG. 8 Mesenteric cyst in a child. The stomach is displaced upward by circumscribed soft tissue mass.

Appendiceal abscesses produce extrinsic pressure upon the cecum when examined with barium. I have excised a large appendiceal mucocele which produced considerable cecal defect, simulating an appendiceal abscess In surveying scout films of the acute abdomen in children one should be on the lookout for fecaliths in the right lower quadrant. Detecting these enables one to make a precise diagnosis in an otherwise problematic case An ileus coupled with the



FIG. 9 Mesenteric cyst. Lateral view



FIG. 10. Homogeneous haze due to ovarian cyst.

shadow of a right lower quadrant fecalith spells almost assuredly a ruptured appendix with spreading peritonitis Pelvic abscesses resulting from ruptured sigmoidal diverticula may displace the rectum to the left. Instillation of a small amount of barium into the rectum may indicate the presence of an internal fistula Pelvic collections are visualized best in the erect or lateral decubitus positions Free fluid in the pelvis assumes a semilunar contour (Figs 11 & 12)



FIG. 11 Ruptured appendicitis due to fecalith. Latter plainly visualized overlying sacrum Diagnosis made from this film.



FIG. 12. Fecalith within appendix. Same case as Fig. 11

Ascitic fluid produces a homogeneous haze obscuring the normal contours of the bowel and of the musculature bulging of extraperitoneal layer of fat may be noted in massive ascites Similarly there is wide separation of individual intestinal loops

Gastrectasis is a significant finding in paralytic ileus, peritonitis and traumatic cases Various types of pyloric obstruction may yield marked gastric dilatation. Filling defects in the magenblassen may point to the diagnosis of carcinoma of the cardiac end of the stomach Dilatation of the stomach and duodenum are common findings in acute pancreatitis here one may actually observe widening of the gastrocolic space due to edema and swelling of the pancreas In necrotizing pancreatitis with retrogastric hematomata actual pronounced defects may be observed in the gastric wall.

Intussusception yields the usual x ray findings of intestinal obstruction, and often one actually may visualize the intussusceptum and the intussuscipiens We have observed in several cases the telescoping of the bowel loops usually the ileum within the ascending colon or transverse colon As the intussusception develops there is a paucity of small intestinal loops away from the site of the lesion. In cases of subacute intussusception with spontaneous reduction we note an ever changing picture as the obstruction appears and disappears Absence of the cecal shadow in the right lower quadrant and visualization of the

intussusceptum into the intussuscipiens enables one to confirm the diagnosis of intussusception As stressed by Ravitch and Morgan fluoroscopic reduction of the intussusception by barium enema has proved very fruitful in reducing the obstruction. To insure full reduc tion one must fill out the meniscus shaped head of the barium column into the ileum This should be demonstrated on films Tight approximation of the buttocks to insure sufficient hydrostatic pressure is essential however external abdominal manipulation is hazardous Repetition of the enema may be necessary where the baby expels the fluid. When the reduction proves ineffectual at the ileocecal area it may be completed surgically through a McBurney incision (Figs 13 & 14)



FIG. 13 Intussusception. Note plain visualization of intussusceptum and intussuscipiens.

Survey film examination is very helpful in traumatic cases Examination de lineates the splenic shadow in the left upper quadrant in a great many normal subjects. It is sharply defined against the outline of the adjacent stomach especially when the latter is filled with gas In a lacerated spleen, the blood gravitates along the gastrolienal ligament be tween the folds of the gastrocolic omen tum thus may produce one or several of the following helpful hints toward arriv ing at a precise diagnosis The greater curvature of the stomach assumes a ser rated appearance because of the juxta position of the adjacent hematoma. The stomach is displaced to the left and the transverse colon downward



FIG. 14 Same case as Fig. 13 Secondary metastasis to humerus from lymphoblastoma producing intussusception. X-ray therapy to arm. Lymphoblastoma of cecum resected. Patient alive twenty years postoperatively

There is an increase in the size of the splenic shadow especially in cases of intracapsular splenic hemorrhage The splenic shadow usually merges with the opacity extending into the region of the gastrocolic omentum resulting in further separation of the two air-distended hollow viscera. In case of shock following lacerated spleen gastrectasis is an associated finding, the stomach ballooning out with a large amount of air These findings made it possible for us to make

a diagnosis of lacerated spleen with delayed hemorrhage four to five days after the injury J Gershon-Cohen and Hermel recommended inspiration and expiration films to demonstrate splinting of the left hemidiaphragm in lacerations of the spleen Lateral decubitus films to note fluid levels may also help in determining the diagnosis

Traumatic or spontaneous hemorrhage into the mesentery is characterized by generalized ileus with anterior displacement of the small bowel this may be shown best in supine position films employing a horizontal ray (Fig 15)



FIG. 15 Ileus due to traumatic hemorrhage into mesentery

Lacerated livers are characterized by splinting of the right diaphragm on respiration, enlargement of the hepatic shadow an ill defined lower hepatic border and a displacement of the stomach to the left, when the right lobe of the liver is lacerated.

Mesenteric thrombosis yields a picture similar to that of ileus In the majority of our cases the small intestinal loops have been only slightly dilated and the degree of intestinal dilatation has been less marked than in obstructive lesions Mesenteric abscess produces a homogeneous radio-opaque shadow within the peritoneal cavity, surrounded by dilated small intestinal loops (Figs 16 & 17)



FIG. 16. Mesenteric thrombosis. Air in small bowel and transverse colon.



FIG 17 Mesenteric thrombosis. Markedly dilated stomach and small bowel.

Occasionally small intestinal obstruction in the elderly patient is due to a gallstone which has entered the small intestine *via* a cholecystointestinal fistula A survey film reveals the usual x ray signs of obstruction plus the presence of a calculus within the small intestine Therefore the film enables one not only to make a precise etiological diagnosis but also to localize the site of obstruction An additional clue to the cholecystointestinal fistula is the presence of striated air shadows within the biliary ducts These may be disseminated over the entire liver or may constitute only a few isolated streaks over the right lobe of the liver (Fig 18)



Fig. 18 Intestinal obstruction. Strangulated hernia.

Volvulus a rare condition has been diagnosed by us several times on the basis of survey x ray films Usually one finds markedly dilated loops of large intestine particularly near the hepatic flexure Since volvulus is invariably associated with considerable elongation and reduplication of the sigmoid which often ascends diagonally to the right subhepatic region before making a downward swoop one finds on careful analysis of the film multiple vertical loops of large intestine in the normal habitat of the ascending colon Extreme degrees of large intestinal dilatation are seen in volvulus. Dilated loops of small intestine having an arcade arrangement suggest a small intestinal mesenteric volvulus rotated about an adhesive band Volvulus of the cecum is typified by marked cecal distention as well as by the presence of distended loops of ileum radiating toward the cecum In the baglike clockwise cecal volvulus the cecum is medial to the small bowel loops in the right lower quadrant and may be noted closer to the periumbilical area (Fig 19)

In tuberculous adenitis one may encounter on occasions complete duodenal obstruction resulting in marked gastrectasis In one of our cases retroperitoneal tuberculous glands caused complete duodenal obstruction because of periduodenal adhesions The stomach was huge



Fig. 19 Volvulus of sigmoid. Markedly redundant large bowel.

occupying practically the entire peritoneal cavity simulating a pneumoperitoneum The patient died rapidly in severe alkalosis A ruptured abdominal aneurysm may simulate an acute surgical abdomen The survey film shows a diffuse homogeneous density to the left of the lumbar spine obliterating the left iliopsoas line Very often one notes either calcific debris within the mass or fine arteriosclerotic plaques within the wall of the aneurysm (Fig. 20) On



FIG. 20. Ileus due to ruptured abdominal aortic aneurysm.

several occasions not only a false diagnosis of some intraperitoneal surgical condition was avoided but also a useless operation (Figs 21 & 22)

While an extended discussion of intra abdominal intestinal lesions in the newborn cannot be undertaken here a few words may be helpful. Congenital small intestinal anomaly may be suspected by the presence of large amounts of small-intestinal gas In two infants there was marked distention of the cecum and ascending colon due to congenital bands extending from the right lobe of the liver and constricting the right half of the transverse colon. Complete or partial intestinal atresia may be suspected from a survey x ray film. In atresia of the sphincter ani, it may be advantageous to examine the baby in complete Trendelenburg position one notes distention of the large bowel including the rectal ampulla, the column of air stopping short of the anus

In the treatment of simple obstruc



FIG. 21 Calcified spleen. Retroperitoneal oxygen insufflation outlining kidneys and adrenals.



FIG 22. Secondary metastasis to liver Thorotrast study

tion small-intestinal intubation through the use of a Miller Abbot, Harris or Cantor tube is of paramount importance It may not be amiss to brief residents on the fluoroscopic control of intubation The most important thing to stress is that one must not spend hours of *needless fluoroscopy in an attempt to* pass the tube into the duodenum lest this result in irreparable harm to both patient and attending personnel. Placing the patient on the right side eliminating undue slack in the stomach, and alternating inflation and deflation of the balloon may greatly facilitate passage of the tube through the pylorus

In instances of very high intraenteric pressure in spite of the above maneuvers the tube will not pass out of the stomach here it is of no avail to persevere with needle fluoroscopy—adjust the tube to yield the proper amount of intragastric slack and return the patient to bed Time and patience (twelve to twenty four hours) may be required for passage of the tube through the pylorus Once the tube has reached the ligament of Treitz, the balloon may be inflated and the tube fed at the rate of 20 cm (8 inches) per hour to reach the terminal ileum It is advisable to aspirate the stomach if it is dilated, to hasten tube entry into the duodenum

Daily scout films are necessary to check the location of the tip of the tube If the progress of the tube is impeded at a given point, the tube may be withdrawn under fluoroscopic control to the proximal jejunum and forward propulsion again attempted to overcome the obstacle previously encountered When the tube is being withdrawn one must be certain that the balloon is collapsed to avoid an intussusception. Coiling of the tube in a figure-of-eight fashion in a dilated small intestinal loop may lead to serious difficulty and should be avoided at all costs

Diminution of gas in the small bowel and entry of gas into the colon are of good prognostic omen. One aims to eliminate all small intestinal gas to as *certain complete deflation of the small* bowel Occasionally in extreme cases of aerophagia, small-intestinal gas may recurrently accumulate proximal to the tip of the tube the significance of this may be largely discounted providing ample amounts of gas are visualized in the colon.

In intestinal obstruction following total colectomy for ulcerative colitis with a permanent ileostomy stoma small amounts of gas may be visualized in the small bowel It is important to recall that intestinal obstruction is a common complication following ileostomy The ileostomy stoma forms a soft tissue shadow on the film not to be confused with an abnormal tumefactive mass

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24

Pathologic Conditions Causing Acute Abdominal Symptoms and Physical Signs

ACUTE pathologic conditions within the abdomen are among the most fascinating aspects of surgical diagnosis The surgeon s acumen is tested on innumerable occasions and often he fails to make an accurate diagnosis Abdominal diagnosis is difficult because many pathologic entities resemble each other and the differential points are infrequently encountered or are difficult to elicit.

In this discussion those conditions most frequently encountered in evaluating the acute surgical abdomen will be emphasized. Thoracic injuries may produce abdominal signs which simulate an intra-abdominal injury By means of a proper physical examination and x-ray investigation thoracic injuries are usually demonstrated. Therefore the differential diagnosis between intra-abdominal and thoracic lesions is not stressed

Even as in medical diagnosis the history presented is a valuable asset to the diagnostician. Thus a complete history is a necessity With a satisfactory history as a background a thorough physical examination is imperative Physical examination of the abdomen is less exact than that of the thorax However both anatomic regions are examined according to the four cardinal procedures of inspection palpation percussion and auscultation

Examination of the abdomen has given rise to certain significant signs which will be described.

Bastedo or psoas test is employed in the diagnosis of appendicitis The patient is placed on the left side the hip joint is fully extended and the thigh abducted. If the psoas muscle is irritated this maneuver produces pain

Blaisdell's sign is elicited in acute appendicitis when the patient is turned on the left side pressure over McBurney s point produces pain

Obturator test is performed by flexing the right thigh and rotating the hip joint internally This procedure puts the obturator internus under tension. An inflammed appendix is irritated by this procedure and pain occurs in the hypogastrium.

Rovsing s sign is valuable when it is present When it is not elicited it does not eliminate the presence of appendicitis. A positive test results when even pressure is exerted over the descending colon which forces gas into the cecum This pressure in the left iliac fossa causes pain in the right iliac fossa.

Dance's sign is found in cecal-colic

Most commonly in adults appendicitis is confused with a perforated ulcer, acute cholecystitis renal disease and in women tubo-ovarian disease. Among the large bowel lesions producing acute abdominal symptoms are the perforations of ulcerative colitis, diverticulitis, and carcinoma In somewhat obese patients an inflammation of an appendices epiploica may present a symptom complex closely paralleling that of appendicitis The symptoms may occur in the right or left lower quadrant. When these latter conditions occur within the abdomen the signs and symptoms of peritoneal irritation are present.

When right sided renal disease is present, the differential diagnosis is aided if pathologic urinary findings are revealed. The clinical picture is atypical of appendicitis and the tenderness elicited is most marked in the lumbar region. A calculus may be visualized by a flat-plate roentgenogram of the abdomen, and may produce a sudden onset of marked involuntary muscle spasm out of proportion to the tenderness Fever may be absent and the white blood count may be normal. Associated with a renal calculus there may be an adynamic ileus It is worth noting that reflex digestive symptoms begin when a calculus enters the ureter

Although appendicitis is the same pathologic process in an adult as in a child, the clinical response to the disease may be extremely different. An upper respiratory infection may be the preamble to acute appendicitis. A child with an apparent acute gastroenteritis whose condition becomes worse may have appendicitis Appendicitis in children may be associated with diarrhea and may not be indicative of a simple enteritis.

With acute gastroenteritis a history of a similar condition in other members of the family may be valuable Gastroenteritis in children produces vomiting which may cause mild or diffuse abdominal tenderness In such cases there is no specific localization of the tenderness as in appendicitis If diarrhea is a manifestation of an inflamed pelvic appendix or peritonitis, rectal and/or abdominal tenderness will be present

Acute mesenteric adenitis is a common entity simulating appendicitis Invariably there is a recent or present history of an upper respiratory infection. Palpable enlarged cervical glands are a prominent feature assisting in arriving at a proper diagnosis. The nodes are enlarged throughout the mesentery as well. Since the nodes in the ileocecal region are numerous the physical signs are more marked in the right lower quadrant of the abdomen. Vomiting is not a common complaint however anorexia and nausea occur frequently Fever may be slight but the white blood count is lower than that seen in classical appendicitis

Inflammation of a Meckel's diverticulum is often confused with terminal ileitis and acute appendicitis For this reason many patients with a diverticulum are operated upon because of a preoperative diagnosis of appendicitis Meckel's diverticulitis may occur in any age group Clinical manifestation of the disease may be hemorrhage or the symptoms of intussusception, or those of appendicitis. The hemorrhage may be a massive bloody stool. When confused with appendicitis it may be diagnosed only at operation. In Meckel's diverticulitis the *initial* abdominal pain occurs It does *not* localize to the right lower quadrant, but may localize to the right paraumbilical area. When the abdominal pain is severe and intermittent and

accompanied by vomiting, an intussusception subsequent to the diverticulum may be suspected



FIG. 1 Photograph taken at the time of operation of an acute inflammation in a Meckel's diverticulum. This diverticulum was found 40 cm. (16 inches) from the ileocecal junction. The preoperative signs and symptoms suggested acute appendicitis.

In children many nonsurgical diseases may simulate appendicitis Among these are typhoid fever measles, migraine blood dyscrasias, and metabolic disorder Disturbance in the physiology of the ileocecal valve may produce a spasm suggesting appendiceal colic. Pathologic processes in the appendix, such as tuberculosis, carcinoid, and mucocele may produce the clinical picture of appendicitis

Mention should be made of the occurrence of a neuroma in an appendix Often this pathologic entity is missed even by the pathologist when the appendix is examined microscopically Neuroappendicopathy usually causes discomfort or a dull ache in the right lower abdominal quadrant with slight tenderness over McBurney's point Occasionally excruciating pain and muscle spasm develop Nausea may occur with or without vomiting. The temperature and leukocyte counts are normal. Recurrent episodes of pain are commonly experienced by the patient. The neuromas are one of two types The ganglioneuroma finds its origin in Meissner's plexus and extends to Auerbach's plexus, and secondarily involves the mucous plexus The commoner plexiform neuroma affects only the deep region of the mucous plexus. These neuromata are identified microscopically by means of the Masson trichrome stain

ACUTE PELVIC DISEASES

A discussion of acute pelvic diseases in women emphasizes two facts First, many ovarian dysfunctions and pathologic entities are associated with various phases of encephalalgia. Secondly inflammatory tubo-ovarian disease may produce urinary difficulty most frequently dysuria.

Recurrent lower abdominal pain mid way between menstrual periods suggests a rupture of a graafian follicle or a corpus luteum Bleeding into the peritoneal cavity may produce symptoms resembling those of acute appendicitis, ectopic pregnancy or other acute surgical condition within the abdomen.

A rupture of an ovarian follicle occurs most frequently in patients between eighteen and twenty-five years of age. It occurs twice as often in unmarried women as in married women Married women occasionally complain that the pain commenced during sexual intercourse Trauma or exertion, however are not true causative factors The chief symptom caused by ovarian bleeding is pain which commences and remains in the right or left lower quadrant Nausea is present in most instances but vomiting is not frequent. Adnexal tenderness is found on pelvic examination. A pelvic mass is not palpated. Leukocytosis usually occurs. A rise in tem-

perature above 101° F (38 3° C.) is infrequent.

Ovarian bleeding not associated with ovulation may be caused by rupture of a corpus hemorrhagicum a corpus luteum or a retention cyst of the ovary The ovary may have endometrial implants which bleed from the ovarian surface at the time of menstruation

When laparotomy discloses ovarian hemorrhage, all possible ovarian tissue should be conserved if possible Suturing for hemostasis is often necessary but oophorectomy is seldom indicated

A ruptured tubal pregnancy may produce severe intraperitoneal hemorrhage The free blood produces peritoneal irritation. With the picture of tubal pregnancy there is a history of menstrual irregularity associated with uterine cramps or enlargement (by pelvic examination) and vaginal "spotting" or real bleeding. The vomiting subsequent to intra-abdominal bleeding is initiated when the peritoneum is irritated After the peritoneal cavity adapts itself to this foreign stimulation the vomiting subsides This is a marked contrast to the state of constant peritoneal irritation secondary to an inflammatory process, when the nausea and vomiting are more persistent

Other sources of bleeding must be distinguished from that due to ectopic pregnancy These other sources may be duodenal and gastric ulcers, gastric neoplasm, esophageal varix, Meckel's diverticulum, and benign tumors of the intestinal wall.

The physical findings of acute salpingitis often closely approach those of appendicitis The differential diagnosis between these two entities frequently cannot be made preoperatively In pyosalpingitis there is no generalized pain localizing to the right lower quadrant. The onset of the pain is more gradual than that of appendicitis Vomiting is delayed longer after the onset of pain and is less frequent Vaginal examination is of the utmost importance. Hyperemia about Bartholin's glands redness of the labia minora, plus a vaginal discharge will assist in the diagnosis Vaginal manual examination may reveal left-sided as well as right-sided tenderness Fixation of the uterus may be noted in chronic cases with acute exacerbation Tenderness of the corpus uteri due to the associated endometritis may be noted A rapid sedimentation rate and a vaginal smear are valuable diagnostic laboratory aids. Conservative therapy employing the antibiotics will alleviate the symptoms in most acute cases

The presence of an ovarian or uterine tumor may not be disclosed until its pedicle has become twisted. The onset of pain is sudden and is associated with a simultaneous outburst of vomiting. The pain is low in the abdomen and in the pelvis When gangrenous changes occur the primary symptoms are rapidly followed by those of a spreading peritonitis The diagnosis may be made by a pelvic examination if the tumor mass is palpable. A movable tender mass not localized to either lower quadrant should suggest a pedunculated cyst or fibroid.

So-called male pelvic inflammatory disease may be confused with appendicitis Inflammation of the intra abdominal portion of the vas deferens produces abdominal pain and tenderness The tenderest point is deeply situated in the middle of Poupart's ligament. It may feel like a fibrous cord in the inguinal canal. Torsion of the spermatic cord may produce a similar state. The onset of acute prostatitis may be instituted with lower abdominal pain. In

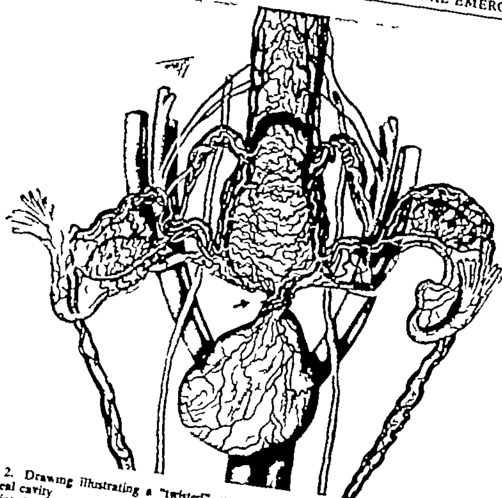


FIG. 2. Drawing illustrating a "twisted" uterine fibroid causing a hemorrhage in the peritoneal cavity

Reprinted from the J.A.M.A., 144 616 (Oct. 21) 1950. (Reproduced by special permission of the A.M.A.) Taken from Rupture of Uterine Vessel by Twisted Fibroid Causing Intra abdominal Hemorrhage By B Bernard Kaye and Bernard J Ficarra.

addition there is marked pain in the perineum and rectum The pain is intensified on urination or defecation and may be referred to the glans penis Fever is moderately high Rectal examination is important. The prostate is tender soft, and enlarged. Also the seminal vesicles are usually enlarged and tender

In the differential diagnosis of appendicitis and acute pelvic disease regional ileitis must be considered This subject is discussed elsewhere in this volume

PERFORATED PEPTIC ULCER

On the emergency service of any large city hospital it will be found that perforated peptic ulcer is next in frequency to acute appendicitis in the causation of acute symptoms and signs within the abdomen. In the majority of instances it can be said that the average patient with a perforated ulcer has the ulcer facies The patient is usually thin and high-strung (lean and hungry look) Usually there is the history of a period of abstinence from food for one two, or more hours preceding the per

foration Many of these patients frequently volunteer a history of drinking alcoholic beverages. The pain occurs suddenly in the epigastrium, rapidly becoming generalized Some patients have stated that the pain was like a "bursting" sensation Vomiting occurs initially but is not a cardinal feature because the stomach empties itself through the perforation Gastric contents fill the peritoneal cavity resulting in excruciating pain.

Physical examination of the abdomen demonstrates true board like rectus rigidity The point of maximum tenderness plus rebound tenderness is in the mid-epigastrium. Often when the rigidity is not classical, appendicitis is thought of as the intra-abdominal pathology The confusion arises because moderate tenderness with rebound is elicited over McBurney s point. This tenderness results from a collection of fluid in the right lower quadrant which gravitates to this location from the perforation above, and this occurs frequently enough to be confusing Confusion can be avoided, however if it is remembered that appendicitis rarely produces tenderness in the mid-epigastrium, although a perforated ulcer may give rise to tenderness in the appendiceal area.

Obliteration of liver dullness occurs in approximately seventy per cent of perforated ulcer cases when the perforation is found on the anterior surface of the duodenum or stomach. This finding is confirmed by x-rays of the abdomen which reveal pneumoperitoneum Percussion along the right anterior axillary line is the most satisfactory location for discovering obliteration of liver dullness (Clark s sign)

Rectal examination is deceiving on many occasions Because of the accumulation of fluid in the pelvis, tenderness may be elicited by digital examination. This finding may lead the examiner to suspect appendicitis

As an aid in diagnosing a perforated ulcer two simple tests may be employed The patient is given a drink of water Following this he will complain of increasing pain or vomiting may be initiated. In some instances an increase in abdominal rigidity occurs The second test is to ask the patient to sit up in bed. If pneumoperitoneum is present, the air will rise to rest beneath the diaphragm irritate it, and bring on hiccoughs.

Mention is made here of the atypical type of perforated ulcer The English surgeons have called these "dry perforations" American surgeons have referred to them as "formes frustes" These are small perforations which heal quickly following the acute attack Many of these patients are treated without operation.

The treatment of choice for an acute perforated peptic ulcer is surgical intervention with repair of the perforation Thoughts have been advanced as to the optimum time for operation. It cannot be denied that the sooner the repair is made following the perforation, the more favorable will be the prognosis One cannot state that after a certain hour thought of operation should be abandoned. Time should not decide operability the patient s physical condition should be the guide. A patient in profound shock must be given preoperative preparation. It has been noted that a patient in shock with a perforated ulcer with a lowered blood pressure, improves with the eradication of pain. This eliminates the neurogenic factor in the production of shock. The patient s operability is greatly enhanced with a rise in blood pressure

Certain patients are encountered who are not operable and conservative therapy directed at combating the peritonitis is the procedure to follow The method of treatment of this condition is discussed elsewhere in this volume

ACUTE CHOLECYSTITIS

The gallbladder patient is usually a moderately obese female The patient with acute cholecystitis may present a past history of gallbladder disease A story of chronic belching flatulence or intolerance to fatty foods may be volunteered Pain is a prominent complaint This pain usually is referred to the right shoulder hypochondrium, or right scapula. Vomiting occurs initially but is not a persistent sign. A history of previous acute episodes is common but not a necessary experience

An acute infection in a low hanging gallbadder is difficult to distinguish from acute appendicitis especially in stout patients The sudden onset of right sided pain with localized tenderness and rigidity in the right upper quadrant plus a fever and an elevated white count indicate cholecystitis Hyperesthesia of the seventh, eighth, and ninth thoracic skin segments has been described in acute cholecystitis (Boas sign) It is best detected below the angle of the right scapula.

Exploratory laparotomy is advocated because perforation occurs in twenty five per cent of patients with acute cholecystitis. In five per cent of these cases a stone is found in the common bile duct, hence exploration of the common bile duct must be entertained at the time of operation

In true cases of acute cholecystitis ninety per cent of patients have a stone impacted in the cystic duct. Gangrene is more frequent in hydrops of the gallbladder than in acute inflammation Hydrops is due to sudden obstruction of the cystic duct (usually by a calculus) When this obstruction occurs the pain is most severe, and radiation of the pain to the back is pronounced

At this point a word is written concerning the onset of sudden jaundice with signs of an acute condition within the abdomen. A clinical picture of this type may indicate a perforation of the gallbladder or the common bile duct

ACUTE LESIONS OF THE COLON

The cecum and ascending colon are close to the appendix Hence when cecal disease processes produce physical signs suggesting an acute abdomen the clinical picture may be attributed to appendicitis Especially is this true when secondary inflammation produces peritoneal irritation or localized peritonitis Diverticulitis may occur rarely in the cecum or ascending colon. In such cases the differentiation from appendicitis is most difficult. Perforation of the cecum with secondary peritonitis has occurred in mechanical obstruction of the large bowel due to rectosigmoidal neoplasm Cecal disease is usually associated with signs of peritonitis and the diagnosis is made only at the operating table The exception to this is primary cecal carcinoma which is revealed by barium clysma Appendiceal abscess is frequently confused with cecal neoplasm and *vice versa*

Physical signs suggesting a "left sided" appendicitis plus a palpable mass may indicate acute diverticulitis of the descending colon or sigmoid When a diverticulum perforates, signs of peritonitis occur rapidly and these should suggest the possibility of other etiologic factors. Perforation may be secondary to ulcerative colitis or carcinoma Left

lower quadrant signs of an inflammatory lesion without the usual complaint of vomiting, plus pain prior to defecation may indicate sigmoiditis

Intestinal polyps may occur anywhere in the colon. Rectal polyps are usually without symptoms except for occasional bleeding or prolapse Polyps in the vicinity of the ileocecal junction can produce abdominal discomfort Excruciating colicky pain with vomiting in a patient known to have a polyp may indicate the beginning of an intussusception

Obstructive lesions of the colon are treated surgically Often a preliminary cecostomy or colostomy is an imperative emergency procedure. A subsequent resection may be performed at a later date Diverticulitis and/or sigmoiditis producing secondary peritonitis may necessitate a colostomy to assist in relieving the peritoneal contamination. Intussusception often demands immediate surgical intervention because of the possibility of gangrenous changes occurring in the involved intestinal segment.

Another type of lesion which may demand surgical exploration is volvulus (twisting of an intestinal segment) This situation may occur in patients with a long redundant or mobile megasigmoid This type of thing with a pedicle like mesosigmoid predisposes to twisting of the rectosigmoid, or sigmoid The sigmoid is the commonest location for a volvulus to occur A possible factor in the development of this anomaly of the sigmoid may be excessive dietary roughage and a congenital maldevelopment.

In the Sept. 1 1951 issue of the J.A.M.A Berger and Lundberg reported an elevated altitude as possibly playing a role in this disease These same authors reported five cases of volvuli associated with lead poisoning They believe that there is a temporal relationship between plumbism and volvulus They concluded that intestinal volvulus may be precipitated by lead poisoning in those instances in which a predisposing factor is present. Elsewhere in this volume there is a discussion of acute abdominal conditions resulting from ulcerative colitis



FIG. 3 Barium enema administered to a fourteen year-old girl with a volvulus of the sigmoid colon. The peak like projection is characteristic of a volvulus as revealed by x rays *via* a barium clysma.

SMALL BOWEL OBSTRUCTION

Any age group may witness the occurrence of small-bowel obstruction. The new-born infant as well as the aged is a candidate for an acute intestinal obstruction.

Congenital atresia of the intestine is to be considered when the infant vomits profusely during the first day of life

Examination of the meconium in such instances is revealing. The absence of cornified epithelial cells in the meconium is presumptive evidence that an atresia exists (Farber's test) Congenital intestinal stenosis may produce the signs of an obstruction during the first week of life. The differentiation from atresia is often impossible X-ray studies are helpful Another congenital cause of obstruction is malrotation of the intestine producing volvulus Therefore the signs of an intestinal obstruction during the first week of life may indicate atresia stenosis or malrotation

Well-known agents in the production of small-bowel obstruction are external hernias They may be present in any age group A hernia may occur through any opening canal, or tissue weakness (i.e the abdominal wall) which surrounds the peritoneal cavity For this reason, any patient presenting the triad of obstruction cramp-like abdominal pain distention, and constipation (or obstipation) should be examined thoroughly for a hernia If this is found, a distinction should be made between simple incarceration and hernial strangulation Strangulations produce vascular embarrassment and the possibility of intestinal gangrene Surgical intervention in such cases is imperative. In severe simple obstruction, preoperative preparation to combat dehydration and azotemia are prerequisites to surgery Briefly hernial strangulations produce fever and leukocytosis early simple obstructions are associated with late fever and leukocytosis

Infrequently internal hernias cause intestinal obstruction Within the abdominal cavity are a number of peritoneal fossae into which the intestine may protrude The most important of these are the duodenal pericecal and intersigmoidal fossae Rarely the foramen of Winslow may contain a hernia. As a generality these are rare conditions and are usually diagnosed at operation Occasionally a hernia is found through a mesenteric tear or rent. Often the explanation of an internal hernia of this type is difficult. In some cases a previous history of a fall or other injury will be obtained A line of force of sufficient intensity can produce a rent in the mesenteric root which many months later is the etiologic agent for an internal hernia

Previous abdominal operation may produce bands and adhesions which cause a small bowel obstruction This is especially true when peritoneal drains have been employed in the lower abdomen Gallbladder drains do not tend to produce bands which stimulate an intestinal obstruction This may be because the omentum adheres to the under surface of the liver thus protecting the intestinal loops

A discussion of intestinal obstruction from matting is appropriate at this point. The matting syndrome as a type of intestinal obstruction was described in the New Orleans Medical and Surgical Journal (104 17 1951) Dense adherence of small bowel to omentum and to an old incisional scar with induration and edema of the entire mass may cause a partial intestinal obstruction requiring immediate surgical intervention This matting syndrome is a real pathologic entity and occurs in a patient with a lower abdominal scar from a previous operation. The acute episode may be accompanied by nausea and the sensation of a "knot" beneath the old scar

Acute cholelithiasis and renal calculi often produce adynamic ileus which may be confused with an intestinal ob-

struction. X ray evidence in such cases is most revealing True small bowel obstruction occurs when a gallstone has entered the gastrointestinal tract to become impacted within the intestinal lumen. The picture of intestinal obstruction in a patient with a previous history of cholecystitis should suggest this condition This is not a rare situation and should be considered in the differential diagnosis of obstruction Especially is this true if the patient has not had a previous operation. This type of obstruction occurs more commonly in women than in men Gallstones large enough to cause obstruction can enter the gastrointestinal tract only through a cholecystenteric fistula. The gallbladder becomes attached to the stomach or duodenum by inflammatory adhesions of the gallbladder wall. Pressure of a large stone will cause ulceration and erosion of the wall of the gallbladder and the adherent stomach or intestine Small stones pass through the intestinal tract and are unnoticed. Large stones become impacted in the narrow lumen of the terminal ileum. Patients with this type of obstruction invariably have azotemia.

It is well to recall that the clinical evidence of intestinal distention in small-bowel obstruction is less pronounced than the distention resulting from large-bowel obstruction.

A further observation of importance is that in an obstruction of the ileum, x-rays (flat plate) may suggest the obstruction site. The point of pathology is usually opposite to the side showing by x-rays the greatest intestinal distention. This is due to a fan-like pattern resulting from any mechanical obstruction to the lower ileum. Thus if x rays reveal more distended loops in the right side of the abdomen, the obstruction-site most likely will be found in the left side of the abdomen The surgeon therefore, will be guided as to where he should make his incision

Emphasis in recent years has been placed on regional or segmental ileitis It was formerly thought that this entity was confined to the terminal ileum Now it is known to involve any segment of the small intestine Nor is it an involvement in continuity Areas of noninvolvement may be present between two involved segments ("skipped" involvement) This disease process is found most frequently in younger people under forty years of age The onset of obstructive symptoms may be insidious but it is often acute In the early stages of the disease symptoms result from inflammation edema, and irritation of the small bowel More commonly the evidence is that of chronic obstruction such as intermittent colicky pain and borborygmi. The pain is in the upper abdomen Nausea with or without vomiting plus diarrhea are frequent complaints Nutritional disturbances (loss of weight etc) occur Eating produces discomfort and aggravates the pain so that these patients restrict their food intake. In addition, the increased intestinal motility and diarrhea result in *impaired* absorption. Therefore in long-standing cases it is not unusual to find weight loss, anemia, hypoproteinemia and vitamin deficiency Occasionally a mass is palpable in the right lower quadrant.

An acute onset of terminal ileitis may be confused with appendicitis and pelvic diseases. The cardinal *differentiating* points found in ileitis are excessive flatulence passage of blood from the rectum diarrhea, and tenderness less marked and less specific than in appendicitis or pelvic inflammatory diseases. Ileitus also must be differentiated from

Meckel's diverticulitis and neoplasm of the ileum Small-bowel neoplasm is comparatively rare forming about three per cent of all intestinal cancers The diagnostic evidence of segmental ileitis is obtained by x ray studies of the small intestine

Intussusception occurs most frequently in children but it may be present *in adults True small-bowel intussusception* is rare. The ileocecal type is common but the commonest types are the cecalcolic and other colonic forms of this disease The predisposing causes of intussusception are Meckel's diverticulum intestinal polyps lymphoma, duplication and long mesenteric attachments

The patient is usually a well-developed individual who gives the story of recurrent abdominal pain associated with repeated and severe vomiting Dehydration and a shock-like state may be present. Children are more frequently affected in their first decade of life During an attack, the child doubles his arms and legs as an expression of pain. Grunting respiration and crying often accompany the clinical picture Pallor may be present. In a "thin-walled" child abdominal palpation may reveal a mass Blood passed by rectum or found on the finger used in examining the rectum may be an aid in arriving at the diagnosis of intussusception. Occasionally in children the intussusception is felt by rectal examination

Twisting of a small intestinal loop producing a volvulus without a previous operation to form bands and adhesions is not common When it does occur the picture is one of acute intestinal obstruction When circulatory embarrassment to the involved loop occurs, gangrene will result. If perforation results, a superimposed picture of peritonitis is produced rapidly

In most pathologic states of the small intestine surgical intervention is almost imperative and frequently is an emergency procedure *A preoperative* period of small bowel decompression by means of an indwelling tube is a life-saving asset to the surgical management *of certain lesions of the small* intestine.

A more complete discussion of the use of suction *via* indwelling tubes appears elsewhere *in this* volume. The importance of x ray diagnosis of small-bowel lesions likewise is stressed in another chapter

LARGE BOWEL OBSTRUCTION

The standard symptomatology of acute intestinal obstruction is cramp-like pain vomiting, obstipation, distention, visible and palpable intestinal patterns through the abdominal wall, and tenderness (due to pressure on distended bowel, not to peritoneal irritation, unless an inflammatory exudate has formed on the serosa and/or the peritoneum) If no etiologic agent in the small intestine can be found as an answer to this symptom complex then a cause should be sought in the large bowel

Simple fecal impaction can cause a large-bowel obstruction. Especially is this true in jaundiced patients who have clay-colored stools The feces at times not only resembles clay in color but also in consistency A simple rectal examination will determine the presence of an impaction. Removal of the impaction will result in a disappearance of the obstructive signs

Colonic carcinoma especially of the descending sigmoidal and rectosigmoidal regions may be the site of an

insidious obstruction In elderly patients obstruction due to rectosigmoidal neoplasm is quite common. A flat plate roentgenogram of the abdomen followed by a barium enema localizes the lesions

Volvulus of the colon may occur in the ileocecal and sigmoidal regions Radiology following a contrast enema is a valuable asset in diagnosis

Colonic intussusception occurs as previously mentioned. In adults the commonest locations are in the ileocecal area and the transverse colon The clinical picture is one of intestinal obstruction plus other evidences of intussusception including x ray findings

Several abdominal conditions are frequently confused with large-bowel obstruction Congenital megacolon (Hirschsprung's disease) may occur in adults as well as in children. Obstruction is suspected when the abdomen becomes distended with a history of no bowel movements for two or three weeks A roentgenogram of the abdomen will reveal a markedly distended colon In long-standing cases anorexia, lassitude and malnutrition are common. This state is distinguished from obstruction by the absence of vomiting and a voluminous bowel evacuation after the obstipation period. Barium enema clarifies the problem.

Ascites, especially that type which is secondary to carcinomatosis, may be confused with an incomplete obstruction because of the distention. Ascites is readily discovered by changing the patient's position. The abdomen is distended, the flanks bulge the midabdomen is flattened, and the umbilicus is obliterated when the patient is reclining. While in this position the abdomen is tense, not tender and tympany is elicited in the upper abdomen, while dullness is present in the flanks By changing the patient's position to one side the other side will demonstrate cessation of bulging in the flanks shifting dullness and tympany The umbilicus may then bulge All these changing signs indicate the presence of intraperitoneal fluid.

Encapsulated fluid, as in a very large ovarian cyst may be deceiving In this instance the abdomen is distended unevenly to one side The bulge is lateral and anterior There is no shifting dullness and no other findings of ascites Movement of the patient results in a limited change in the mass On occasion an associated edema of the lower abdomen and labia may be noted. A valuable aid in diagnosis is to compress the tumor against the abdominal aorta this will result in a transmission of the aortic impulse to the tumor so that the mass appears to pulsate.

Reflex paralysis of the colon may occur from an acute intraperitoneal inflammatory lesion. The cause for this may be an inflammatory lesion within the abdominal cavity cholelithiasis, or renal calculi

PRIMARY PERITONITIS, SO-CALLED

A form of peritonitis due to certain specific organisms, and not resulting as a complication, has been termed primary peritonitis However these cases of peritonitis occur secondary to an infection elsewhere. In female children (ten years of age and younger) pneumococcic and streptococcic peritonitis is frequently encountered. The infection is thought to spread from the fallopian tube.

The patient is usually a poorly nourished child. The onset is abrupt, with generalized abdominal pain which does not localize Fever of 104°F (40 C.)

Idiopathic infarction of the greater omentum is not a common disease It is found usually at operation when a patient is subjected to an emergency operation with the erroneous preoperative diagnosis of acute appendicitis The etiology of this lesion is not clearly understood however the location of the infarct strongly indicates that an anatomic cause may be the answer This anatomic reason is suggested because the venous return in the omentum predisposes to thrombus formation in the lower right segment.

At operation the omentum presents a hemorrhagic infarction with varying degrees of gangrene The peritoneal fluid is serosanguinous This entity is seen usually in obese patients over fifty years of age The treatment consists in resection of the involved omentum

TRAUMATIC ABDOMINAL INJURIES

All penetrating abdominal wounds demand surgical exploration if there is any suspicion that the peritoneal cavity has been entered Observation may be justified in nonpenetrating abdominal injuries In such instances it is well to remember that injury to solid abdominal organs, such as the liver and spleen produces hemorrhage with its associated shock Injury to hollow viscera causes peritoneal irritation and later peritonitis, when a perforation actually occurs

When blunt trauma injures the gastrointestinal tract, the small bowel because of its anterior position in the peritoneal cavity becomes the victim of the blow Less frequently the stomach and rarely the colon are injured following blunt trauma to the abdomen. Perforations in the stomach present a clinical picture similar to a perforated peptic ulcer Colonic perforations result in a rapidly spreading peritonitis because of the numerous organisms in the colon. Thus the symptomatology of colonic perforation is one of a rapidly spreading peritonitis Surgical intervention in both colonic and gastric perforations is imperative

In small-bowel perforations the most important contribution made by the patient is given in the history A story of "blunt trauma" followed by abdominal pain is most significant. Persistent, continuous, or intermittent pain associated with vomiting or hematemesis may indicate small-bowel perforation. Hematemesis may occur in perforations near the duodenum or ligament of Treitz. Perforations in the jejunum are usually single and occur on the antimesenteric border of the intestine When the ileum is the site of perforation the segments near the ileocecal region are involved. Perforations in this locality are usually multiple but are often single A patient with small-bowel perforation may be able to walk and show no signs of an abdominal calamity until many hours after the injury

In the usual case examination demonstrates an acute surgical condition within the abdominal cavity When a decision cannot be reached as to operability frequent repeated physical examinations are important. The pulse and blood pressure should be recorded hourly or more frequently if possible A steadily rising pulse rate after the initial shock of injury has subsided is especially significant Often a varying picture may be presented without any definite physical signs The patient may eventually enter the hospital for an associated minor injury or because the first noted symptoms were those complicating the injury (most often perito-

nitis) The presence of shock may reveal itself many hours after the injury This may be because of the leakage of intestinal contents into the peritoneal cavity following an initial walling off of the perforation Symptoms and signs of peritonitis are present when this situation exists

An accurate diagnosis may be reached occasionally by means of a flat plate roentgenogram of the abdomen A crescent of air accumulating under the diaphragm can be demonstrated in positive cases

A rather rare type of injury is a subparietal puncture of the intestine due to muscular effort. An explanation offered for this injury is that muscular effort increases the intraluminal pressure of the intestine In the presence of a weak point in the parieties as at a hernial site a bursting rupture takes place Postoperative bands and adhesions which permit a stretching of the intestine between two fixed points may cause it to rupture Signs of an acute surgical condition rapidly occur in such instances

Crushing injuries to the abdomen may cause lacerations or compression of the liver (rupture of the capsule) spleen, or kidneys Such injuries are characterized by blood-loss plus peritoneal signs When blood escapes into the peritoneal cavity signs of peritoneal irritation will ensue Liver injuries produce right upper quadrant pain which extends to the shoulder and back. Increasing dullness may be elicited in the right upper quadrant (see Chapter 25)

Splenic rupture is often associated with rib fracture Pain in the left upper quadrant extending to the left axilla or shoulder may occur Tenderness and rigidity on the left side of the abdomen are present in classical cases. By roentgen examination it may be found that a lacerated spleen is causing serration of the greater curvature of the stomach or widening of the gastrocolic space due to hemorrhagic infiltration.

Renal injuries following trauma are characterized by lumbar pain which radiates to the thigh and genitalia. Abdominal pain is generalized without tenderness The sacrospinalis muscles contract and are tense to palpation Hematuria with the above signs indicates contusion or laceration of the kidney (see Chapter 51)

Rupture of the urinary bladder may or may not be associated with fractures of the pelvic bones. It always occurs when the bladder is distended an empty bladder does not usually rupture Pain in the region of the urinary bladder following an injury or accident is strongly suggestive of bladder injury If an intraperitoneal rupture of the bladder occurs, signs of peritonitis occur rapidly In an extraperitoneal rupture, urinary extravasation may be delayed. Rarely blood "dribbling" from the urethra is seen By instilling sterile water into the bladder and then aspirating it, the presence of a ruptured bladder may be indicated The instillation of an opaque fluid and air into the bladder followed by a roentgenogram of the abdomen is a diagnostic aid. The opaque material is found in the peritoneal cavity and the free air ascends beneath the diaphragm Intravenous pyelogram is a valuable asset in arriving at a diagnosis

Retroperitoneal hemorrhage may result from a fractured pelvis, renal injury or from small vessels in the lumbar areas The blood supply of the perinephritic fat is derived from branches of the main renal, adrenal and spermatic arteries These arteries and veins form a network about the kidney Hence, these vessels are torn easily when

the kidney is moved by an external force.

The clinical picture of retroperitoneal hemorrhage is one of posthemorrhagic shock. In addition the abdominal muscles are rigid. In thin patients a longitudinal mass is palpable through the abdominal wall. This swelling corresponds to a distention of the lateral ligamentous fold as a result of the underlying extravasated blood. Because of a rich plexus of nerves about the kidney (arising from the dorsal roots of the eleventh and twelfth spinal nerves) intestinal distention follows within twenty-four hours. In the years before the antibiotics infection in the retroperitoneal space was almost always fatal.

Frequently children ingest foreign bodies. These cases are usually treated without surgery. Frequent physical examinations and x rays of the abdomen should be made to note the progress of the foreign body. Each stool should be investigated for the object ingested. Open pins and jagged and irregular foreign bodies may scratch the anus and initiate minor bleeding. Intestinal perforation due to an ingested foreign body is not common. However an ingested foreign body may perforate an obstructed loop of intestine. When perforation does occur the omentum or a loop of intestine may become adherent to the perforation so that signs of peritonitis are delayed.

PANCREATIC DISEASES

Classical acute pancreatitis presents a most dramatic clinical picture. The patient is in shock with a subnormal temperature. The pain is severe and radiates straight through to the back. Vomiting is immediate profuse and heavily bile-stained. The patient is usually obese with moderate cyanosis about the face. The absence of abdominal rigidity in the presence of an acute abdominal catastrophe is significant. Tenderness may be present in the left costovertebral angle. As the disease progresses lumbar discoloration is noted (after forty-eight to seventy two hours). This is due to direct action of the pancreatic juices which escape *via* the retroperitoneal space to the surface (Turner's sign). Occasionally a yellow discoloration may occur about the umbilicus (Johnston's sign). In some cases a past history of gallbladder disease or jaundice is elicited.

Several tests have been devised as diagnostic aids in acute pancreatitis. The mydriatic test of Loewi employs adrenalin. This drug has no effect upon the pupil of a normal person but in acute pancreatitis dilatation of the pupil occurs. Laboratory tests in pancreatitis are valuable. Urine normally contains ten to twenty units of diastase but in acute pancreatitis the value may rise to 100 or 200 units. Blood amylase is elevated and remains high several hours following the onset of symptoms. Later it falls without recession of the disease and is not significant. The symptoms of pancreatitis often resemble those of a posterior gastric ulcer which has perforated into the lesser peritoneal cavity. It is also confused with small-bowel obstruction and acute cholecystitis. Acute pancreatitis is frequently diagnosed with certainty only when the abdomen is opened. The finding of blood-stained fluid and areas of fat necrosis scattered throughout the peritoneal cavity indicates acute pancreatitis. Surgical drainage of the biliary tract is the current method of treatment. Some authorities believe that if the diagnosis is established the treatment should be nonsurgical.

A line of force striking the abdomen may produce pancreatic injury resulting in traumatic pancreatitis In such instances the patient presents the clinical symptoms of acute pancreatitis The mode of the pathologic process is based upon Brocq s idea that pancreatitic necrosis is due to self-digestion resulting from the activation of trypsinogen into trypsin. This activation is brought about by trauma to the abdomen which compresses the pancreas An elevation of the serum amylase follows the injury The elevation is probably due to absorption of the enzyme into the blood after the enzyme has been expelled into the interstitial spaces or peritoneal cavity

Every surgeon has examined a patient with severe abdominal pains and absent physical signs Confusion becomes more acute when the pulse is normal, and the temperature and blood counts are within normal limits Such a patient may have pancreatic calculi. Epigastric pain resembling "indigestion" or gall bladder colic is the most prominent symptom When this pain is associated with vomiting acute pancreatitis is suspected. This is especially true if there is an associated pancreatitis Glycosuria, suggesting painful diabetes, may indicate pancreatic calculi. The diagnosis is made by roentgenograms of the abdomen. Since the stones are composed of calcium carbonate they are revealed by x rays The calculi may be removed surgically without undue complications.

ACUTE PHYSIOLOGIC DISTURBANCES PRODUCING ABDOMINAL SIGNS AND SYMPTOMS

There are many nonabdominal conditions which manifest themselves as acute abdominal complaints. Such disorders are characterized by their systemic rather than their abdominal origin

Profound physiologic disturbances such as uremia or diabetic acidosis may be accompanied by abdominal pain and muscle spasm In these conditions however the abdominal signs are usually poorly localized and shifting. When abdominal distention occurs in Addison s disease an acute intestinal obstruction may be suspected especially when the pigment has been overlooked In some cases the low blood pressure in Addison s disease has been thought to be a part of the symptomatology of shock.

Some blood diseases are associated with abdominal complaints. Sicklemia (drepanocytosis) features abdominal pain during an exacerbation of the disease (crisis) Splenic pain is frequent, presumably associated with infarction Many of these patients have tibial ulcers X-ray studies of the skeletal system are a great aid in diagnosis Blood studies reveal the sickle cells and an elevated reticulocyte count.

Acute leukemia may cause signs suggesting appendicitis. This may be due to leukemic infiltration of the appendix without inflammation. This disease is identified by the bleeding gums, and the abnormal white cells found in the blood smear

Purpura is a disease altering the number of platelets in the blood Certain types of this disease may produce abdominal symptoms. In Henoch s purpura, hemorrhage occurs in the gastrointestinal tract. It also occurs in and around the appendix, so that signs of appendicitis may occur Before the skin and joint lesions become manifest this disease may be confused with an acute surgical condition within the abdomen Blood studies, evidence of bleeding elsewhere, and a positive Rumple Leede s

test (production of petechial hemorrhage by applying a pressure cuff to the arm) are valuable diagnostic aids Intussusception and mesenteric thrombosis are confused with Henoch's purpura when blood is passed by rectum

Cardiovascular diseases present a difficult problem in diagnosing abdominal conditions on frequent occasions Myocardial infarction and pericarditis can produce epigastric pain similar to that of a perforated ulcer However specific abdominal signs are absent. Congestive heart failure causes general visceral congestion so that nausea, vomiting, and abdominal distention occur Digitalis derivatives may also produce nausea and vomiting Electrocardiograms in these cases are especially useful in arriving at a diagnosis

Aneurysm of the abdominal aorta can produce pain in sufficient degree to arouse suspicion of an incipient intra abdominal catastrophe However the pulsating mass is often felt and its visualization by x rays identifies it. Dissecting aneurysm of the abdominal aorta produces severe abdominal pain which "goes" straight to the back and radiates up and down the spinal column Shock develops as the disease progresses The absence of abdominal findings eliminates intra-abdominal disease as the cause for the pain. A similar extension of pain is imitated by a stretching of the mesentery of the small intestine as occasionally seen in certain cases of incarcerated inguinal hernia Shock is absent and the release of the incarceration results in a disappearance of the pain.

Allergic smooth muscle spasm which simulates acute surgical abdominal states should always be in the mind of the abdominal diagnostician A clinical picture simulating appendicitis or some other acute condition may develop due to gastrointestinal hypersensitivity A previous history of any type of allergy such as asthma, eczema, or urticaria, is important The clinical picture of abdominal allergy is atypical. Previous similar attacks terminating in recovery constitute valuable historical data. The relief of symptoms by adrenalin or antihistamine preparations, and the presence of an eosinophilia indicate the possibility of an allergy

Two conditions which do not usually have an antecedent or coexisting allergic history are serum sickness and black widow spider bite Serum sickness following an injection of a vaccine or serum can result in abdominal symptoms similar to those produced by an allergy Black widow spider bite produces an anaphylactoid reaction which may result in abdominal complaints similar to any allergic reactions. In these cases the generalized *urticaria or* angioneurotic edema, the joint pains, plus a "shock like" state cautions the examiner that the abdominal *findings* may not be due to a surgical condition within the abdomen The importance of the history in these cases is self evident. The presence of muscular rigidity elsewhere than in the abdomen, as in the extremities and face is found frequently following a bite by the black widow spider

Certain *infectious diseases produce* abdominal signs on occasion most often tenderness This sign plus a history of pain may lead one to suspect appendicitis. Mention of typhoid fever and similar enteric diseases, brings forth the value of a history of diarrhea Peritonitis appendiceal abscess and occasionally uncomplicated appendicitis are associated with diarrhea Diarrhea plus a low white count tends to rule out ap-

pendicitis A positive Widal test con firms the presence of typhoid fever

Measles may cause toxic changes in the appendix which may produce signs of appendicitis However the presence of Koplik s spots leukopenia, and a his tory of exposure will clarify the picture

Pneumococcic infiltration of the right base of the lung is notorious for simulat ing appendicitis A thorough examina tion of the chest followed by an x ray study of the thoracic area will reveal the underlying pneumonia With the ex ception of pneumonia, most of the systemic diseases confused with appendicitis cause a leukopenia and not the leukocytosis which is so common in appendicitis

Intoxication from alcoholic beverages may produce signs simulating an acute condition within the abdomen. Alcohol ism of the chronic type is associated with varying degrees of gastritis. Some of these patients enter the hospital following over-indulgence with a resultant exacerbation of their gastritis symptoms Pain, vomiting, and at times epigastric tenderness may suggest the presence of an atypical perforated peptic ulcer Ac curate observation of such patients often will avert an unnecessary operation

Chronic lead poisoning is likely to be attended by attacks of abdominal pain. The history the lack of physical findings, and the absence of a rise in the pulse rate and/or fever eliminate seri ous abdominal disease. A negative history of exposure to lead does not ex clude the probability of the disease Many persons are exposed to lead compounds unknowingly The presence of a blue lead line at the edges of the gums assists in arriving at a correct diagnosis Examination of a whole blood smear reveals "stippling" of the red blood cells in classical cases of plumbism In some cases an increased lead output in the urine is conclusive evidence

A most unusual disease is porphyria It is a constitutional metabolic disease characterized by an excessive elimina tion of porphyrins in the urine The disease patterns are divided into two categories

(1) Chronic congenital porphyria

(2) Acute toxic or acute idiopathic types in which the chief complaints are referable to the gastrointestinal tract (or to the nervous system) It is the acute idiopathic type with gastrointestinal symptoms which may be confused with a condition within the abdomen suggest ing an emergency

In acute porphyria the abdominal pain is rapid in onset, although vague premonitory pains may have been expe rienced previously The pain is colicky and may be associated with nausea, vomiting and constipation. X ray study of the abdomen demonstrates loops of intestine distended with gas (If the patient is operated upon through a diagnostic error intestinal hyperperistalsis with local or general spasm of the intestines is seen)

The clinical picture often is bizarre and may simulate acute gallbladder disease or acute renal colic An aid in diagnosis by physical examination is the neurological pattern of acute por phyria This pattern is revealed by neuritic pain and paresthesias The in volvement of motor nerves often leads to a wrist drop or a foot drop (or both) As the disease progresses there is an ascending paralysis, with pain and muscular atrophy Other late central nerv ous system symptoms are listlessness nervousness convulsion, delirium, and even psychosis

The characteristic laboratory findings

of the disease are relative to the urinalysis which reveals an excessive amount of porphyrins in the urine The distinctive characteristic in reference to the urinary findings is the change of color of the urine so that it looks like red wine When the urine is exposed to cold air this change is accelerated The change in color is further accelerated when the urine is exposed to ultraviolet light. The prognosis in this condition is most unfavorable, with death occurring from one to one and a half years from the onset of the disease. Elective surgery therefore in acute porphyria should be approached with very great concern and thought.

Another metabolic disease causing acute abdominal pain is essential hyperlipemia. This disease results from a disturbance in fat metabolism From the point of view of this discussion abdominal pain in hyperlipemia is noted. This pain may be persistent or intermittent and is associated with tenderness and rigidity The pain may commence around the umbilicus and localize to the right lower quadrant or the pain may remain in the center of the abdomen or radiate to the upper abdomen Nausea and vomiting may be present. This disease may simulate acute pancreatitis or appendicitis

The diagnosis is assisted by the presence of lipemic retinitis (revealed by ophthalmoscopic examination) eruptive xanthomatosis, and the enlargement of the liver and/or spleen. Laboratory aids are elevated total blood lipids and a rise in cholesterol or phospholipids The serum itself is creamy or milky white An unnecessary laparotomy will be avoided if the abdominal symptoms are recognized as a clinical expression of essential hyperlipemia.

NEUROLOGIC DISORDERS CAUSING ABDOMINAL SYMPTOMS

An adequate neurologic examination is necessary in some instances of diagnostic problems associated with abdominal symptoms Many pathologic conditions of neurogenic origin may masquerade under symptoms which are not directly associated with the organ involved The gastrointestinal tract is the frequent victim of symptoms which are not indicative of digestive disturbances Intra-abdominal disease expresses itself most often through the symptoms of nausea and vomiting. Thus, if a patient presents these symptoms, attention is immediately attracted to the gastrointestinal tract. However thought must be given to pathologic entities of the nervous system which may express themselves in gastrointestinal complaints

Among those entities producing gastrointestinal complaints whose major pathology involves the nervous system are

(1) Fracture of skull with or without brain injury
(2) Cerebral concussion
(3) Meningitis
(4) Cerebral vascular accidents
(5) Sinus thrombosis
(6) Cerebral tumors
(7) Ménière's disease
(8) Hydrocephalus
(9) Epilepsy
(10) Cerebral syphilis and tabes dorsalis
(11) Migraine

Acute vomiting with or without nausea in cerebral lesions occurs suddenly In trauma to the skull vomiting may occur during the stage of cerebral irritation Vomiting is rarely a

solitary symptom in the above pathologic entities. A thorough physical examination readily identifies the neurologic disease Some neurologic diseases however are more difficult to segregate from true abdominal disease

As a generality it can be stated that the abdominal pain of neurologic origin is in the abdominal wall rather than in the viscera The gastric crisis of tabes dorsalis is the commonest cause of abdominal pain of neurogenic origin In tabes there is no area of abdominal tenderness. The temperature and white blood count are within normal limits. Abdominal muscle spasm even rigidity may confuse the clinical picture The presence of positive signs of tabes identifies the true underlying pathology The most constant findings are inability to stand erect with the eyes closed, a small fixed pupil which does not respond to light (Argyll-Robertson pupil) absence of knee reflexes and Babinski sign. If the patient is asked to walk, the typical ataxic gait is suggestive Positive serologic tests are conclusive. It must also be remembered that acute intra-abdominal lesions can occur in tabetic patients

Herpes zoster and intercostal neuralgia produce pain along the course of thoracic and abdominal nerves In these conditions the absence of abdominal signs and the systemic response to infection is an asset in eliminating the underlying disease

Occasionally spinal nerve compression caused by disease of the spinal column will produce pain. Here as in most neurologic lesions the pain is in the abdominal wall rather than beneath it.

Paroxysmal abdominal pain due to epilepsy has been noticed in children This pain is described by the patient as being periumbilical and epigastric in location It may or may not radiate to the lower abdomen or lumbar regions The pain is sudden in onset, knife-like in severity and transitory in duration, from minutes to hours Other associated gastrointestinal symptoms of this type of epilepsy are anorexia nausea vomiting and diarrhea A valuable aid in diagnosing this type of epilepsy associated with abdominal symptoms, is to employ the electroencephalograph

As a conclusion to this discussion of those pathologic conditions causing acute abdominal symptoms and signs it should be remembered that correct diagnosis is not essential to correct treatment. When an honest, sincere effort has been made to arrive at an accurate diagnosis and it has been fruitless the next important decision to make is whether or not immediate operation is indicated An accurate evaluation of the patient's operability is preferable to an accurate diagnosis Diagnostic honesty in error is more laudable than surgical intervention with death. A "spot-diagnosis" may be spectacular but it is unstable

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CLAUDE E WELCH M D

25

Traumatic Rupture of the Spleen and Liver

TRAUMATIC RUPTURE OF THE SPLEEN

RUPTURE of the spleen may occur from penetrating wounds or blunt nonpenetrating trauma, while in rare instances there may be a spontaneous fracture of the diseased or apparently normal spleen Although the treatment of the two types of rupture is similar they must be considered separately since diagnosis is much more difficult in the latter group

PENETRATING WOUNDS

Penetrating wounds of the spleen are usually due to shell fragments, bullets or lacerations with a knife The various signs and symptoms of splenic rupture appear at a variable interval These features however must not be awaited by the surgeon who must remember that every penetrating wound of the peritoneal cavity or of the diaphragm requires a laparotomy The path of the missile must be reconstructed, and if abdominal penetration is certain or even possible exploration is necessary

A significant characteristic of penetrating abdominal wounds is that viscera are injured in exact relation to their cubic contents In other words, the intestine and colon will be involved commonly in such wounds and the spleen rarely In a series of war wounds,[8] it was shown that with penetrating trauma, the spleen was involved in 10 8 per cent of cases, compared with sixty four per cent in which the intestine or colon was injured With blunt trauma solid organs are far more likely to fracture Thus, in a group of cases observed in civilian life where blunt trauma is encountered most frequently[8] the spleen was injured twice as commonly as the small intestine and colon.

When foreign bodies lodge in the spleen, infection usually results The spleen tolerates their presence poorly so that secondary hemorrhage and abscess formation are relatively common unless splenectomy is carried out at an early stage

RUPTURE DUE TO BLUNT OR NONPENETRATING TRAUMA

This is the type of injury commonly observed in civilian life Here, diagnosis is more difficult because in most instances only very slight or no damage to the overlying skin can be detected Rupture most commonly follows a fall auto accidents, football injuries, or blows directed to the region of the spleen It is important to note that the injury is often apparently trivial Thus, a fall from a height of 1 meter (3 feet) may be enough to rupture the spleen

The important diagnostic features are

1 Pain This is characteristically located in the left hypochondrium from which it may spread to the flank groin or right side depending upon the amount of blood extravasation. The intensity likewise depends upon the amount of free blood present. When free blood comes into contact with the diaphragm, severe pain in the left supra clavicular area occurs This is accentuated when the patient lies flat or is in Trendelenburg position so that he usually prefers to sit semierect

2 Shock. Immediately after rupture, the patient usually becomes pale and apprehensive This is commonly followed by temporary improvement and is succeeded by the full blown signs of shock when blood loss has been sufficient to produce them

3 Nausea and vomiting may occur but neither is frequent or severe

4 Physical findings Local tenderness accompanies the blood extravasation It usually is not particularly striking unless there is a large amount of blood in the peritoneal cavity Moderate spasm accompanies the tenderness As a blood clot forms in the left upper quadrant, percussion will demonstrate an increasing area of dullness

5 Examination of the blood by red count or hematocrit is useless in early stages before hemodilution has occurred. Blood volume estimates will show that intraperitoneal hemorrhage has occurred long before the hematocrit falls and they give an accurate estimate of the blood loss. After twenty four hours a fairly clear estimate of the amount of hemorrhage may be secured by the hematocrit. The white cell count is quite variable and of no importance in diagnosis

6 The x-ray examination is valuable in several ways In the first place it may demonstrate fractures of the left 8th to 12th ribs or of the transverse processes of the first two lumbar vertebrae. Fractures of any of these bones should always raise the suspicion of a ruptured spleen In our series such fractures occur in approximately eighteen per cent of all ruptured spleens

The splenic shadow should also be noted on a film taken with the patient sitting up In equivocal cases succeeding pictures a day or more later may show an increase in size of the shadow indicating progressive hemorrhage More accurate delineation of the spleen can often be secured by the introduction of barium into the gastrointestinal tract. A swallow of barium may show the stomach displaced to the right and a barium enema given with caution, demonstrates a lowered splenic flexure

7 Diagnostic paracentesis sometimes gives information of value *but only if it is positive* After novocain infiltration, a fine needle is inserted through the abdominal wall in the left hypochondrium Bowel injury is avoided by the continued introduction of novocain until after the peritoneum has been entered If several drops of blood are obtained, the test may be considered positive If no blood is obtained, paracentesis is carried out in each of the other quadrants A false positive test occurs occasionally if a vessel in the abdominal wall is entered. Usually however and particularly in early cases no blood is aspirated If no blood is obtained, it is important that the surgeon regard the test as entirely uninformative not militating against the diagnosis of splenic rupture In our series of cases, the test was found to be free of hazard, but of value in only about a third of the cases in which it was used.

Spontaneous rupture of the spleen has

been noted in each of sixteen different diseases accompanied by splenomegaly according to Hershey and Lubitz.[3] They found that it was by far the commonest in malaria and were able to collect sixty five such cases from the literature in a thirty year period. There have also been numerous reports of rupture when the spleen has been involved by infectious mononucleosis In a few instances, an apparently normal spleen has ruptured though nearly always a history of minimal trauma can be obtained.

Pathology At the time of injury a frank rupture of the body of the spleen and capsule may occur If the major vessels are injured near the hilum exsanguinating hemorrhage and death may occur within a few minutes This is very rare usually the clot produces a tamponade which temporarily stops the bleeding Within a few hours or days, the clot retracts and a secondary hemorrhage occurs Thus secondary hemorrhage is often much more serious than the original and if it occurs after a period of hours or days in which the patient apparently was normal, is known as "delayed rupture" of the spleen In very rare instances, the hemorrhage may cease and a firm clot form with spontaneous recovery Late evidence of this sequence is sometimes manifested by a calcified hematoma in the region of the spleen demonstrated by x rays Occasionally there may be a subcapsular fracture with slow continued bleeding resulting in a hemorrhagic pseudocyst.

Delayed Rupture· This term is rather loosely applied to those cases in which the patient apparently recovers from the initial injury and signs of rupture are not apparent until several hours days or weeks after the original trauma. In one instance delayed rupture was reported two years after the original trauma. The frequency and date of delayed rupture assume considerable importance because only in this fashion can it be determined how long patients suspected of rupture should be kept under observation. In a comprehensive study of 177 cases collected from the literature Zabinski and Harkins[10] concluded that about fourteen per cent of ruptured spleens demonstrate a secondary rupture Half of the cases occurred within a week of the accident, and ninety per cent of them within three weeks We therefore believe it is wisest to keep patients suspected of splenic injury in the hospital for seven days and in close touch with it for another three weeks

Treatment of Splenic Rupture

Preoperative Treatment As soon as the lesion is diagnosed the patient is prepared for operation The important preoperative measures include the administration of blood and the emptying of the stomach A transfusion should be started with provision for several others to be given, if necessary by pressure Intra-arterial transfusions are more difficult technically and since they occasionally lead to serious sequellae should be used only rarely

If the patient has eaten recently he should be encouraged to vomit and the stomach washed out with a large tube A Levin tube is then inserted, and retained until the postoperative ileus subsides This is a most important feature since these patients are not infrequently injured after large meals and may succumb to the aspiration of vomitus during the anesthesia

Anesthesia The safest anesthetic agent is gas-oxygen-ether An intratracheal tube is helpful to secure relaxation, and is essential if there is any

accompanying laceration of the diaphragm Because of the concomitant shock spinal anesthesia is contraindicated, and curare and pentothal must be used with caution

Incision Numerous satisfactory incisions are available, and the choice must be determined by the individual case If there is doubt about the diagnosis or if other viscera also may be injured, a left paramedian incision is best, since it will provide rapid access to the entire peritoneal cavity When the diagnosis apparently is definite, and particularly if the costal flare is broad, an oblique subcostal incision will be very satisfactory A thoracoabdominal approach will be necessary if the diaphragm is injured as well

Operative Procedure While several operative procedures have been employed, splenectomy is the only one that should be used. Packing of a subphrenic hematoma or suture of the capsule of the spleen furnishes insecure methods for the control of hemorrhage Furthermore, since removal of the spleen leads to no untoward physiological sequellae there is no reason to avoid it.

Usually free blood is encountered as soon as the peritoneum is opened. Occasionally none is visible but a hematoma is found by the exploring hand in close proximity to the spleen The laceration is usually palpable before it is visible The spleen nearly always is quite mobile so that it is easy to put a hand above it just below the diaphragm and draw the spleen downward and forward. Large moist packs are inserted behind it. Thus the organ is elevated into a more accessible position, its retraction into the depths of the phrenic fossa by respiratory movements prevented, and bleeding partially controlled by the mechanical tamponade

Thereafter the splenectomy may proceed in a more leisurely fashion in either of two ways Preferably the spleen is rolled forward and to the right, so that the splenic vessels are approached posteriorly The lienocolic ligament is divided between clamps, exposing the lower pole of the spleen. The tail of the pancreas now is observed in close proximity to the splenic vessels and must be displaced gently posteriorly so that it is not damaged The splenic vessels can now be secured, the vasa brevia divided, and the spleen removed. A word of caution is necessary about the vasa brevia. They must be clamped and divided with care since it is possible to lacerate the wall of the stomach as they are mobilized.

The second way to approach the splenic vessels is by the anterior route. Either the gastrocolic omentum is divided or the omentum is separated from the colon so that the lesser peritoneal sac is opened widely The splenic vessels now will be found lying in close apposition to the upper surface of the pancreas Here they can be clamped. With the bleeding now under control, the spleen can be freed of its attachments and removed. This method is the better one to use when the spleen is hard to mobilize and is bleeding profusely since control of the hemorrhage is achieved rapidly It may also be necessary if the body of the spleen has been nearly completely severed from the pedicle

The method of ligature of the splenic vessels is extremely important since a poor tie may be fatal. Theoretically it is best, and usually possible to isolate artery and vein and ligate them individually Two ties are placed on each vessel, an ordinary square knot and a

stitch-ligature distal to it. When time is pressing, a mass ligature of the splenic pedicle is permissible, again, it is necessary to place two ties for safety When the mass ligatures are used, heavy catgut is preferable to nonabsorbable sutures since in the presence of fat silk is more apt to slip

There is great variation in the anatomical disposition of the splenic vessels The artery occasionally runs within rather than above the pancreas It divides at a variable distance from the hilum of the spleen Similar variations are encountered in the splenic vein

When the spleen and all fragments of it have been removed, blood clots are aspirated hemostasis assured, the peritoneal cavity inspected for other injuries and the abdomen closed without drainage

Postoperative Complications The most important complications following splenectomy are hemorrhage subdiaphragmatic abscess pancreatitis, venous thrombosis and rupture of the stomach Severe postoperative hemorrhage follows inadequate hemostasis and, because the splenic artery usually is bleeding, is fatal unless re-exploration is carried out within a few minutes Incomplete hemostasis may also lead to a hematoma and a secondary subphrenic abscess Hence, continued oozing from diaphragmatic adhesions should indicate drainage at the time of operation. Pancreatitis follows trauma to the tail or body of the pancreas incurred during mobilization of the spleen If such trauma has occurred, it is best to drain the region of the tail of the pancreas by a cigarette wick brought out through a stab wound in the left flank at the conclusion of operation. Venous thrombosis involving either the crural or mesenteric systems is not uncommon after splenectomy Fortunately after splenectomy for traumatic rupture it is much less likely to occur despite the fact that there often is a spectacular rise of platelets immediately after the operation Rupture of the stomach may follow unrecognized injury to the wall of that viscus at the time of operation.

Prognosis It must be assumed that the nonoperative therapy of ruptured spleen carries a prohibitive mortality though obviously no accurate recent figures are available The mortality of penetrating wounds of the spleen in World War I was about sixty-three per cent, and in a representative series from World War II twenty four per cent.[7]

In civilian life many patients with severe injuries die before they can be treated by operation The mortality rate of patients who can be operated on now should be zero if there are no associated injuries but technical errors are common enough to result in a significant number of deaths In a recent Massachusetts General Hospital series, the mortality for all patients with ruptured spleens was 13.2 per cent In the group in which operative therapy was possible the death rate from splenectomy was 5 9 per cent

TRAUMATIC RUPTURE OF THE LIVER

The liver may be damaged either by penetrating wounds or by blunt trauma

Penetrating Wounds. They are produced most commonly by shell fragments, bullets, or stabbing with a knife or other sharp instrument Because of the large size of the viscus it is particularly vulnerable to this type of injury The diaphragm and colon are the commonest viscera injured simultaneously The chief effects of stab wounds are manifested by hemorrhage and in case

a bile duct has been severed, by drainage of bile Missiles in addition may result in fragmentation and devitalization of portions of the liver

Since all penetrating wounds of the peritoneal cavity must be explored the preoperative diagnosis of liver injury in this group is interesting but not essential

Rupture Without Perforating Wounds This is by far the commonest type of traumatic rupture observed in civilian life Automobile accidents falls from a height, particularly from suicide attempts, and direct blows to the region of the liver are the commonest causes In general terms liver lacerations are associated with more severe injuries than those of the spleen This feature has been noted by many observers and is confirmed by the fact that associated injuries to other parts of the body are commoner with rupture of the liver than with rupture of the spleen. Together rupture of either or both spleen and liver account for approximately three-quarters of all intraperitoneal injuries observed in civil life

The injury of the liver may vary from a small subcapsular laceration to complete fragmentation of the viscus. Most series of statistics indicate that the right lobe is involved about five times as frequently as the left. There is a tendency for the liver to crack in a stellate fashion. Rarely the capsule may remain intact while the inner portion of the liver is destroyed this is the so-called central rupture of the liver When the right lobe is torn, the dome is involved most frequently

Symptoms and Signs. Pain is noted first in the epigastrium and right hypochondrium. As hemorrhage increases, pain becomes apparent in the right lower quadrant. If blood comes into contact with the diaphragm pain will be felt in the right supraclavicular area Tenderness and spasm usually are minimal at the outset because of the protection of the costal cage The early tenderness is elicited most satisfactorily by heavy percussion with the fist over the lower ribs Later it becomes more definite and with accompanying spasm of moderate degree, indicates progression of peritoneal contamination by blood or bile

Clinical evidence of shock may be entirely absent or severe It must be emphasized that in the early hours after injury blood volume determinations are the only means by which the degree of shock can be measured objectively Not until hemodilution is effected about twenty four hours after injury will the hematocrit or red cell count give an accurate estimate of the patient's blood loss

Examination by x rays is important. Early plates may show fractures of any of the 9th to 12th right ribs or of the right transverse processes of the first two lumbar vertebrae Such fractures should always raise the question of an accompanying rupture of the liver Later elevation and relative fixation of the right leaf of the diaphragm may appear The liver shadow may increase in size Evidence of paralytic ileus may develop with distention of isolated loops of small intestine and colon, and fluid between the coils

Diagnostic paracentesis should be carried out, but a dry tap must not be regarded as evidence against a laceration of the liver On the other hand, if blood can be aspirated from the peritoneal cavity laparotomy must be carried out.

Treatment Many authorities in the past have stated that liver wounds, if they can be diagnosed preoperatively should be treated conservatively In

favor of this point of view it may be observed that many of the patients have stopped bleeding at the time of operation so that the laparotomy is diagnostic rather than therapeutic and the operation itself carries certain hazards

On the other hand, most surgeons believe early operation should be carried out in all cases because it is only in this fashion that the diagnosis can be made and concomitant lesions excluded, because control of hemorrhage will be carried out more effectively and because provision for external drainage of bile should always be made to prevent a bile peritonitis It is advisable to operate on all patients with liver injury as soon as feasible As Mikal and Papen[9] have emphasized, the optimum time for surgical intervention is within three hours of the injury

Many patients with severe liver injuries are not available for operation within this interval. Usually a short period of resuscitation is necessary and provision made for a generous amount of blood to be used during the operative procedure. Here as Beecher[1] has emphasized undue delay is not warranted since surgery is an integral feature of resuscitation

There are however a number of patients who are seen at a later interval with equivocal signs of liver damage following blunt trauma, or who apparently are improving spontaneously In these instances of minor injury it is agreed that it is best to watch the patient closely and operate only if he fails to improve or if he gets worse Conservative measures include nasogastric suction with the intravenous administration of fluid, electrolytes, and blood and antibiotic therapy Suction is maintained for two to three days until ileus has subsided and normal peristalsis can be heard

Anesthesia Gas-oxygen-ether is the best anesthetic agent, preferably administered through an intratracheal tube.

Preoperative Treatment In most cases early operation will be carried out. Preoperatively, the stomach must be emptied blood replacement begun, and antibiotic therapy instituted A Levin tube is inserted to be maintained for several days after operation

Incision The usual incision is a right paramedian, since other portions of the peritoneal cavity may be explored through it. When a liver injury alone is practically certain, an oblique subcostal incision is best in broad-chested individuals. Neither of these incisions is adequate when the upper portion of the liver is traumatized. Here, a thoracoabdominal incision will give the only adequate exposure it is by far the best for extensive lacerations and is essential when the diaphragm has been injured, but is too extensive to be required for all cases. It is better in the usual case, to make an abdominal incision and convert it to a thoracoabdominal if necessary

Operative Procedure The purposes of operation are to establish the diagnosis, to stop hemorrhage to remove sections of devitalized liver and to provide for external drainage of bile

As soon as the peritoneum is opened, free blood, clots and liver fragments are aspirated. The laceration can usually be detected rapidly by palpation after which it should be visualized by appropriate retraction

Often hemorrhage will have stopped at the time the liver is exposed In a series of 829 cases of perforating wounds of the liver treated by the Sec

ond Auxiliary Surgical Service in World War II hemorrhage had ceased in ninety-one per cent of the total at the time of laparotomy [4] In most civilian cases, the time-lag before operation will be less so that a higher percentage of patients will be bleeding at the time of operation Several measures are available for the control of continuing hemorrhage The best method is to pack the laceration with absorbable gauze. For small tears, gelfoam soaked in thrombin should be placed, and for the larger ones oxycel gauze It must be recalled that large quantities of these substances act as foreign bodies, and may suppurate and be expelled later For this reason no more than necessary should be used, and cigarette wicks laid down to this area

Some bleeding lacerations can be sutured by deep catgut sutures These should be of large size (#1) so that they will not cut through the liver and should be introduced by large curved blunt needles. A series of these sutures may be placed, gelfoam introduced into the laceration and the sutures tied over it.

Huge clefts in the liver may have to be packed with large gauze packs While adequate immediate control of bleeding may be achieved by this method, there is always the danger of infection and of a secondary hemorrhage when the pack is removed. Individual suture ligature of torn major arterial vessels occasionally may be possible

The control of hemorrhage will often tax the ingenuity of the surgeon and sometimes be impossible When bleeding is profuse, temporary digital occlusion of the portal vein and hepatic artery by an assistant who passes his index finger through the foramen of Winslow may be of great aid This temporary compression cannot be maintained over twenty minutes or irreparable damage may result, as demonstrated by Wangensteen [6]

Débridement of the liver may be necessary if large portions are devitalized It is better to detach these fragments at the time of the original operation since they may produce large abscesses that are very difficult to drain At the same time, if penetrating foreign bodies can be found and removed without undue trauma, this should be done. Shell fragments are well tolerated but those that carry in bits of clothing or bone fragments are particularly apt to produce late abscesses

It must be emphasized that secondary surgery for penetrating wounds of the liver whether it be for the drainage of abscesses the removal of foreign bodies, or the control of secondary hemorrhage, is very unsatisfactory and that in most cases proper initial surgery should render these other procedures unnecessary

Finally drainage must be instituted. This is primarily to provide for the escape of bile should an intrahepatic duct prove to have been divided. One or more cigarette wicks are placed next to the laceration and preferably brought out through a stab wound in as direct a course as possible One wick also is placed in Morrison's pouch since most drainage will collect at this spot. Special care must be taken if the diaphragmatic surface of the liver has been torn It may be necessary to cut a portion of the suspensory ligament to allow the proper placement of drains They are brought out either anteriorly just below the costal margin, or posterolaterally below the diaphragm near the tip of the 12th rib If a pack has been neces-

sary It should not be brought through the laparotomy incision because infection and wound dehiscence may follow

POSTOPERATIVE CARE The patient is maintained on full doses of antibiotics with adequate blood fluid, and electrolyte replacement. Cigarette wicks are started on the seventh day and removed gradually thereafter over a period of several days Care must be taken with long wicks running over the diaphragm lest they be removed too rapidly and a residual abscess occur

If it has been necessary to place a large pack in the liver it is best to remove it seven or eight days after the primary operation If a later date is chosen the walls of the cavity may become fibrotic the cavity fail to collapse and further bleeding occur later Removal of a large pack should be done in the operating room under anesthesia so that if undue bleeding occurs immediate control may be secured by repacking or laparotomy

Late Complications: Late complications are not infrequent Hemorrhage sepsis and bile peritonitis are the commonest. The use of large packs in the past often led to local sepsis in the liver and abdominal wall and dehiscence of the laparotomy incision. Even in the absence of packs subhepatic or subdiaphragmatic collections of blood or bile are not uncommon and must be drained according to accepted technics If drainage is not prompt, bile empyema may result, to be succeeded in some cases by a bronchopleural fistula

Injuries of the Gallbladder and Bile Ducts Perforating wounds in rare instances cause damage to the gallbladder or to the extrahepatic biliary system Laparotomy is essential to prevent death from bile peritonitis When the gallbladder is involved, either a cholecystostomy or cholecystectomy may be done When the wound is small and the gallbladder not devitalized, a catheter is sutured into the defect by two purse string sutures In other cases a cholecystectomy is carried out

In isolated instances the common duct has been partially or completely divided by a shell fragment. The duct must be repaired or anastomosed and provision made for biliary decompression by the insertion of a T-tube through a normal portion of the duct, either above or below the site of injury It is also essential that the lateral peritoneal attachments of the duodenum be divided and this viscus be turned forward so that an accompanying wound of this organ will not be overlooked

Prognosis The prognosis of liver wounds is difficult to estimate since many of the lesser injuries are either not diagnosed or treated conservatively On the other hand severe lacerations such as those due to a fall from a great height are immediately fatal and never reach the operating table In World War I the mortality from liver wounds was sixty six per cent A representative series of war wounds from World War II was reported by Madding, Lawrence, and Kennedy[4] Their mortality for all cases was twenty-eight per cent, but when the liver was the only viscus damaged, it was 9 7 per cent, and over ninety nine per cent of the injuries were due to penetrating missiles The mortality in civilian life where blunt trauma is commoner is much higher Wright Prigot, and Hill[9] report a gross mortality of 81 3 per cent in a series of thirty two patients with traumatic rupture due to nonpenetrating wounds observed in the Harlem Hospital Mikal and Papen[8] studied forty similar cases from the Boston City Hospital with an overall mor

tality rate of 62.5 per cent. It is probable that these high figures will be reduced by the use of the newer hemostatic agents

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26

Management of Penetrating Abdominal Injuries

EVERY penetrating wound of the abdominal wall and those through the back must be considered as probably having injured intra abdominal organs. Such injuries may be caused by projectiles such as bullets, shell fragments, or like objects metal or otherwise as a result of explosive energy or by nonprojectiles such as knives swords picks, and like objects metal or otherwise Also injuries through the chest or through the inguinal or gluteal regions are potential sources of intra-abdominal trauma particularly if projectile in type, depending upon deflection or the position of the patient at the time of the injury This is well exemplified by a bullet striking the thorax from a higher level or by one striking the gluteal region from a lower level or while the individual is in a stooped over position These patients may die from shock, hemorrhage or infection

Any suspicion that the course of the traumatic agent could have resulted in injury to the contents of the abdomen or pelvis is sufficient cause for exploration of the abdomen Every open wound on the abdominal wall must be considered as having penetrated the peritoneal cavity and having injured an abdominal organ It is better to do an exploratory operation than to assume the risk of natural body protective mechanisms saving the patient s life from the effects of a ruptured viscus In some instances a few hours of observation may be indicated to evaluate the patient. During these hours of observation and evaluation, the patient should receive nothing by mouth nasogastric suction is instituted enemas and rectal instillations are omitted antibiotics are prescribed and the water electrolyte balance blood volume, and serum protein levels protected If one chooses to continue to manage these patients by nonoperative methods and the patient survives, the right guess is good fortune but the wrong guess is fatal

A careful history with details of circumstances, a proper examination and an acute imagination of possibilities by the surgeon are mandatory Proper examination includes evaluation of the patient s general condition for shock and means should be taken to combat this immediately If profuse abdominal hemorrhage is occurring there is no recourse except adequate blood, exploration of the abdomen and an attempt to stop the hemorrhage Frequently in

patients with penetrating abdominal injuries the usual signs of peritoneal irritation such as tenderness and rigidity are not clearly expressed the first few hours after injury For a period of time pain is often not severe even though a hollow viscus has been perforated. By the time severe abdominal pain, tenderness, and rigidity make their definite appearance these patients begin to have the typical facies of severe injury and changes in the pulse, blood pressure, and leukocyte count make their appearance In this interval, blood should be made available for transfusion Scout films of the abdomen should be made in the prone and lateral positions and upright if possible to locate the position of any foreign body as related to the wound of entrance or exit and for any evidence of intraperitoneal gas collection, fluid levels or bone injury The bladder should be catheterized and the urine examined for red blood cells If any remote possibility of rectal injury exists, the patient should be proctoscoped in the lateral position. Blood in the rectum or a perforation of the rectal wall will be conclusive evidence of a perforating injury of the intestinal tract. As in wounds elsewhere patients require a booster dose of tetanus toxoid or tetanus gas antitoxin. Nasogastric suction is instituted and the tube is kept in place during the operation. If the patient is not in shock or after the shock condition has been corrected insofar as possible and blood has been made available to meet any emergency abdominal wounds are managed in the following manner

If there are no signs of intra-abdominal injury it is still mandatory that the abdominal wound be debrided and explored into the depths of the abdominal wall under local or general anesthesia If the peritoneum has been perforated regardless of whether abdominal symptoms or signs have developed, an incision is made elsewhere and the abdomen explored In general, it is a good rule always to make an abdominal incision aside from the site of the traumatic abdominal wound except in the very large destructive type of wound An adequate right or left paramedian incision, depending somewhat on organs presumed injured is usually better than a transverse incision because difficult problems in both the upper and lower abdomen may be present. There should be no temerity about extending it from the costal arch to the pubis In injuries of the upper abdomen where there is a possibility of injury to the diaphragm or thorax, a left or right paramedian incision should be made and then if it is necessary to open the thorax, the incision can be angled off across the left or right costal arch into the 8th interspace or over the 8th rib which may be resected. Proper attention to an additional injury of the thorax or diaphragm may be given through this abdominothoracic approach Before extending the incision into the thorax, the surgeon should check with the anesthetist to be sure that intratracheal anesthesia is in progress and that evaluation and proper preparation of the patient for thoracotomy have been made.

The wounds of entrance and exit are usually debrided after the laparotomy Smaller wounds, like the wounds of entrance and exit of a bullet, are debrided and not closed. Under usual civilian circumstances and if treatment is within eight hours the larger wounds may be closed with continuous or interrupted chromic catgut sutures to the peritoneum, interrupted chromic catgut to the fascia, and interrupted silk sutures to

the skin Under military circumstances unusual civilian circumstances or after eight hours marked potentialities of wound infection exist Under these conditions the peritoneum and fascia layers are closed in a similar manner fine mesh petrolatum gauze is laid in the wound (not packed) and skin closure is delayed Interrupted skin sutures of silk may be placed at the time and tied four to ten days later after removal of the gauze or the delayed placing and tying of the sutures may be done four to ten days later Also closure of wounds may be accomplished by interrupted wire sutures through the fascia, muscle and peritoneum, with skin closure being delayed if advisable With marked destruction of tissues and where one is not able to accomplish closure by developing muscle or fascial flaps because of loss of tissue some type of metal screen may be used to cover the defect. Any operative incision is closed in the usual manner of the surgeon s choice However the principle of interrupted sutures absorbable or nonabsorbable such as catgut, silk, or braided wire for the musculofascial layer including the peritoneum or after closure of the peritoneum followed by closure of the skin with interrupted silk sutures is a preferable method Heavy braided silk or wire sutures through all layers including the skin is a method which is occasionally indicated and proves satisfactory if sutures are placed every 2.5 centimeters (1 inch)

The first problem in penetrating abdominal injuries may be control of massive hemorrhage from various abdominal vessels This is followed by adequate exploration of all organs in a routine manner usually from above downward, closure of any viscus excision of nonviable tissue and removal of foreign material. One should drain a contaminated retroperitoneal space The retrorectal space should be drained alongside of the coccyx in injuries of the rectum. In this day of antibiotics and chemotherapeutic agents the peritoneal cavity is usually not drained after proper toilet of the peritoneal cavity but occasionally under some circumstances one or both lumbar gutters may be drained far laterally through stab wounds

HEMORRHAGE FROM INTRA ABDOMINAL INJURIES

Injuries to the larger vessels such as the abdominal aorta and vena cava usually result in immediate fatal exsanguination or the patient succumbs before reaching the hospital or the operating room A smaller injury to a large vessel may permit only slow extravasation and the developing blood clot under pressure by tension of tissues may delay a fatal hemorrhage or a false aneurysm may develop only to rupture later under some stress or strain Retroperitoneal or intraperitoneal hemorrhage may simulate a ruptured viscus and diagnosis is most difficult. Retroperitoneal hemorrhage if not progressing, should be treated conservatively but injury to a kidney with urinary extravasation should always be excluded by intravenous pyelogram studies If by a set of circumstances one is so fortunate as to encounter a perforating injury of a large vessel which has not proven fatal before the abdomen could be opened the perforation may be compressed between the thumb and finger or the vessel may be compressed above and below the bleeding point. An attempt should then be made to bring the vessel under complete control by rubber-shod bulldog vessel clamps or by passing a loop of umbilical tape or very heavy suture material beneath the ves-

sel above and below the site of injury bringing the ends through the loop and then traction will control the bleeding vessel while sutures are placed (Fig 1) The blind use of regular hemostats should be avoided insofar as possible until one has identified the bleeding vessel However such instruments may occasionally be necessary to meet the

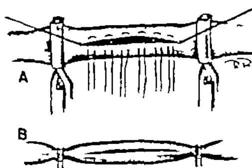


FIG. 1 Control of bleeding from injured blood vessels by rubber-shod bull dog clamps or loops of umbilical tape or heavy suture material, and closure of defect by interrupted everting mattress sutures of fine silk.

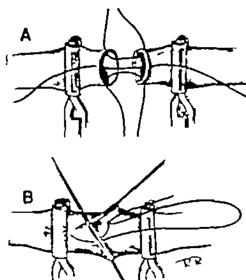


FIG. 2. End-to-end suture of a blood vessel. Three or four interrupted sutures are placed equidistant and closure accomplished between these guide sutures with continuous or interrupted everting mattress sutures of fine silk.

emergency and more rarely may be left in place and prove life saving An available Potts clamp may be applied to a larger vessel after proper exposure and bleeding has been temporarily controlled by tape traction After exposure and identification of the bleeding vessel the perforation is closed by interrupted everting mattress sutures of the Halsted type or by a continuous everting suture (Fig 1 and 2) The suture material should be fine #0000 or #00000 silk, using a fine curved atraumatic needle with suture attached. These blood vessel sutures are kept in sealed tubes containing liquid petrolatum The sutured area may be supported by a small amount of absorbable hemostatic gauze or cotton The need for anticoagulants is debatable and they are probably not indicated in this type of vascular surgery There are a few case reports of survival after ligation of the abdominal aorta below the renal arteries but ligation of this vessel should be avoided if at all possible The vena cava has been ligated rather frequently below the renal veins Some of these patients have only minimal lower extremity disturbance while others have varying difficulties with edema. The iliac arteries and veins may be ligated and usually collateral circulation is adequate However repair of any larger vessel is probably preferable Umbilical tape or heavy silk ligature material should be used for ligating large vessels The use of vessel homografts is now being developed in a few medical centers

Recent experiences with ligation of the splenic and hepatic arteries in the management of portal hypertension promotes some security for ligation of these vessels when necessary if they are injured in penetrating wounds of the abdomen. Repair of these vessels in blood

infiltrated tissues would be most difficult. After ligation of the splenic artery it is not necessary to do a splenectomy but with ligation of the vein only splenectomy would be preferable as the spleen enlarges considerably following splenic vein ligation With ligation of both vessels splenectomy is recommended

Ligation of the hepatic artery should be feasible if it is found to be injured and fatal hemorrhage has not ensued However ligation of this vessel near the hilus of the liver is likely to prove fatal. Such patients should receive penicillin or aureomycin therapy An injured portal vein requires an attempt at repair There are several reports where patients survived ligation of the portal vein and if repair or an anastomosis to the vena cava is not feasible, ligation may be done Compression of these vessels at the foramen of Winslow along the free margin of the hepatoduodenal ligament will usually bring the bleeding under control.

Injury and ligation of vessels supplying the stomach cause no concern because of a most extensive anastomotic connection of vessels within the gastric wall Injury and ligation of the superior mesenteric artery before the middle colic, right colic and ileocolic arteries and some of the vessels to the small intestine are given off are of grave concern and an attempt to repair or anastomose should be made *Ligation of* intestinal vessels below the level of the above-mentioned branches may be done with varying degrees of interference with blood supply to the remaining ileum and cecum The vessel communicating pattern within the mesentery of the small intestine and particularly in the wall of the small intestine is very extensive Lengths of small bowel up to fifteen centimeters (6 inches) with complete ligation of arcuate vessels and vasa recta have been known to survive Close critical observation of any bowel segment after vessel ligation will determine whether resection is indicated and the extent of small bowel to be resected Hot saline packs and injections of one per cent novocain into the mesentery may assist the circulation Antibiotics postoperatively also reduce the risk of infarction

Injury and ligation of vessels to the colon are more likely to result in such interference with the blood supply as to result in the need for intestinal resection. Ligation of either the right colic or left colic artery before their division into ascending and descending branches or of the middle colic before its division into right and left branches, is potential for colon resection but not necessarily because with preservation of the vascular arcade and the marginal vessels, there may be an adequate blood supply Here again the use of calm observation, warm saline packs and novocain injection of the mesentery may prove advantageous and a colon resection avoided Ligation of the main branches of these colic arteries with blocking of the vascular arcade or the marginal vessels usually results in inadequate blood supply to the segment. If tissue survival of the intestine is debatable resection or exteriorization is the safer course *The intestinal wall vessel anastomosis* is not as extensive in the colon as in the small intestine and complete recovery of tissue is not so dependable and any discoloration is more significant as to the necessity for a colon resection

INJURY TO ABDOMINAL ORGANS

Injury to Extrahepatic Biliary Tract. Free bile present in the peri-

toneal cavity requires minute search for the source of bile leakage. Even if an obvious injury to the liver could be the source of bile complete exploration of the extrahepatic biliary tract is indicated in patients with penetrating abdominal wall injuries. If the gallbladder has been perforated, it is usually better judgment to do a cholecystectomy because any bleeding into the gallbladder from injury on the liver surface attachment following closure of a perforation may result in cystic duct obstruction by blood clots and its complications An injury to the fundus may be managed by cholecystostomy through the site of perforation but a delayed cholecystogram study should be made before removing the catheter One should never remove the gallbladder until it has been ascertained that destructive injury to the common duct has not occurred, because the perforated gallbladder might well serve as a means of directing bile into the gastro-intestinal tract by some type of a cholecystogastrointestinal anastomosis With a perforation of the common duct, search is made for both anterior and posterior wall injury and an attempt is made to close any posterior wall perforation, but this may prove most difficult. However if this is not possible, a T-tube covering the posterior wall may give adequate protection A fairly good sized T tube is placed in the common duct at the site of injury and the duct reconstructed over the tube If the common duct has been completely divided, an attempt should be made to introduce a T tube above or below the transection and then the duct should be reconstructed over the tube employing interrupted chromic catgut sutures The use of vitallium tubes may be indicated in some injuries Injury of the common hepatic duct or of the right or left hepatic ducts will usually be associated with injury to the large vessels in the region of the portis hepatis and fatal hemorrhage will probably have occurred If a perforating wound exists or if actual destruction of a segment of either hepatic duct has occurred, an opening may be made in the common duct, a T tube inserted, and an attempt made to reconstruct the duct over a limb of the T-tube If there is also injury to the other hepatic duct, a small catheter may be placed in this duct and brought out along with the T-tube Splitting one end of the transverse arm of a T tube to form a Y has been recommended. Complete destruction of the hepatic ducts, where reconstruction using ductal tissue is impossible calls for transection of the jejunum and bringing the distal end up to the area. In the best way possible with or without catheter or vitallium tube but preferably over a catheter after the method of Allen, the structures should be brought together to permit bile to leave the liver and enter the jejunum The jejunal continuity is then reestablished by an end-to-side anastomosis Injury to the lower end of the common duct will usually be associated with injury of the duodenum or pancreas Regardless of what may be necessary to repair the duodenum or pancreas, a bile flow tract to the stomach, duodenum or loop of jejunum must be established if not intact. Ligation of the common duct and cholecystojejunostomy may be the procedure selected. In all injuries of the extrahepatic biliary tract, the subhepatic area and right upper lumbar gutter must be adequately drained.

Injuries to Pancreas and Duodenum The seriousness of such injuries depends upon the area injured and whether or not it has been overlooked

at the time of exploration An injury may be overlooked because of a hematoma. The lesser injuries to the tail and body of the pancreas may be closed by fine interrupted silk sutures to the capsule and overlying peritoneum and fat. Drainage of the lesser sac is established through the gastrocolic omentum and an abdominal wall stab wound. If there is marked destruction or a severe amputating-like laceration of the tail or body of the pancreas the pancreas may be transected, the capsule closed with fine 000 interrupted silk sutures and drainage of the lesser sac and the peritoneal cavity established. A sump type drain may be used, inserting a smaller catheter inside a mushroom catheter and establishing mild suction to the smaller catheter when necessary All drains from the pancreatic area should be brought out through stab wound incisions and never through the abdominal incision

Injury to the head of the pancreas is usually associated with injury to the common bile duct and duodenum and the mortality is very high. The duodenum must be opened widely Any common bile duct injury is managed as previously described, regardless of injury to the pancreas Usually repair of the *pancreatic duct cannot be accomplished* because of its small size and the traumatic edema and hemorrhage If there is a posterior or medial duodenal wall perforation leading directly into the pancreas it is probably better not to close the perforation but to suture the pancreas to the duodenum in such a manner as to prevent duodenal leakage into the peritoneal cavity and yet permit the pancreas to drain into the duodenum Drainage to the area must be established A perforation of the duodenum on the posterior wall leading to the retroperitoneal space must be closed from within the duodenum and the retroduodenal space drained (Fig. 3) In serious injuries involving the duodenum and pancreas, the stomach should be transected just proximal to the pyloric ring and a gastrojejunostomy established to prevent food traffic through the duodenum (Fig 4) Drainage should be established for both the lesser sac and the right lumbar gutter Banthine is prescribed to decrease pancreatic function This is a treacherous area, threatened with complications, and the mortality is very high.

Injury to the Stomach Any suspicion of a perforating injury to the stomach demands thorough exploration of the anterior gastric wall followed by division of the gastrocolic omentum and careful search for injury to the posterior gastric wall. A pursestring suture mattress sutures or figure of eight sutures are used to close these perforations, preferably in two layers with a deeper suture of catgut and a supporting seromuscular suture of silk. A tag of omentum may be brought into the area and

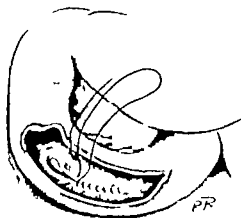


FIG. 3 The duodenum is adequately opened to expose posterior wall The perforation or laceration is closed by a running catgut suture through all walls everting the mucosa toward the lumen side.

secured If there has been sufficient destruction of the gastric wall to cause an hour glass constriction when closure is made one has the choice of several procedures and the choice will depend upon existing circumstances The opening on the anterior or posterior wall may be used for the site of a gastrojejunostomy a sleeve type of resection may be done or the stomach may be completely transected the distal seg-



Fig. 4 Following a destructive injury of the stomach, the area may be transected, the distal segment closed, and the proximal end anastomosed to the jejunum. The jejunum is brought up anterior to the colon with the proximal limb to the lesser curvature.

ment closed, the jejunum brought up anterior to the colon with the proximal limb to the lesser curvature, and an end to-side gastrojejunostomy accomplished (Fig. 4) The latter procedure is preferred. An injury to the cardiac portion of the stomach adjacent to the cardioesophageal junction can be managed by transecting the area and reimplanting the esophagus into the stomach if repair would seem to result in obstruction Postoperative care includes nasogastric suction for two or three days as in routine subtotal gastrectomies

Injury to the Small Intestine Injury to the distal duodenum or first segment of the jejunum demands careful search for a perforation on the posterior wall where fatal leakage may occur into the retroperitoneal space if not identified Incision of the peritoneal reflection below the descending segment of the duodenum permits exploration of the area and drainage. Suspicion of in

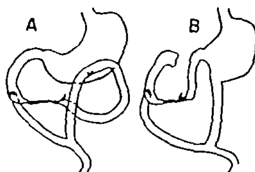


Fig. 5 With severe destruction or narrowing of the duodenum and if a duodenojejunostomy is not feasible a Roux Y procedure becomes necessary In method A a loop of jejunum is brought up anterior to the colon and anastomosed to the stomach in the isoperistaltic direction. The jejunum is transected distal to the anastomosis, the distal end anastomosed to the duodenum, and bowel continuity reestablished by an end-to-end anastomosis. Method B is preferable although a more difficult procedure.

jury to the posterior duodenal wall warrants incision on the anterior wall of the duodenum for exploration These perforations should be closed from within the duodenum (Fig 3) Excessive destruction of tissue or narrowing by suture of the distal duodenum requires duodenojejunostomy or if it is not possible to construct an adequate duodenojejunostomy some type of a

Roux Y procedure becomess necessary (Fig 5)

Almost any penetrating injury of the abdominal cavity from any direction may result in a perforation of the small intestine and under all circumstances, even if only a remote possibility exists careful search should be made beginning at the ligament of Treitz. The intestine is stripped inch by inch and perforations closed as encountered. It has been said that perforation of a hollow viscus always means two perforations will be found—namely wound of entrance and wound of exit—and that therefore it will always be an even number One must work under this premise but frequently the number of perforations is uneven because the perforating object catches only the margin of a hollow viscus Careful search is the only answer to this problem.

Intestinal perforations may be closed by a number of methods With small perforations a single pursestring suture of #000 silk is usually adequate (Fig 6) or the perforation may be closed in the transverse direction with several interrupted mattress, or figure of eight silk sutures Large perforations should be closed by an inner row of continuous #00 chromic catgut Connell sutures further secured by interrupted Lembert, mattress or figure of eight silk sutures in a transverse direction (Fig 6) Two adjacent perforations are better closed by incising between the perforations to make a larger opening and then closing in a transverse or an oblique direction to the longitudinal direction of the bowel (Fig. 7) Interrupted figure of eight sutures of silk for the seromuscular layer of the intestinal tract are dependable and are easily placed A severely traumatized segment of small intestine should be resected. If a segment of small intestine less than 7.5 cm. (3 inches) in length is severely lacerated or perforated an alternate method is to ligate the mesenteric vessels to the area and crush the intestine with Payr clamps to insure death of tissues The proximal side is then intussuscepted into the distal

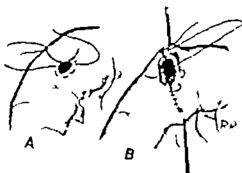


Fig. 6. A. Small perforation closed by a pursestring suture of #000 silk. These may also be closed in the transverse direction by several interrupted mattress or figure-of-eight silk sutures. B Larger lacerations are closed by a continuous #00 chromic catgut Connell suture in the transverse direction. This is supported by a layer of interrupted #00 silk Lembert, mattress or figure-of-eight sutures.

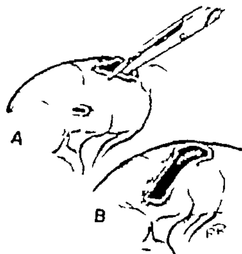


Fig. 7 The tissue between the two small adjacent perforations is incised forming a single large laceration which is closed as in Fig. 6.

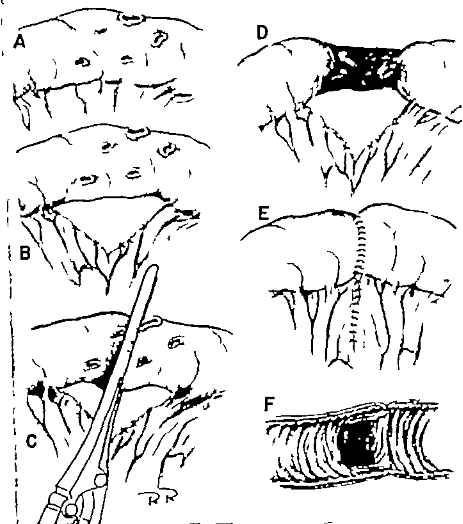


FIG. 8 Segments of severely injured or gangrenous small intestine may be resected, followed by end-to-end anastomosis. An alternate method is depicted. In segments of small intestine of 7.5 cm. or less with severely lacerated or multiple puncture wounds or gangrene, the vessels of the mesentery are ligated (B) and the intestine adequately crushed to insure death of tissue if not already gangrenous (C and D) The proximal segment is intussuscepted into the distal side and a row of interrupted silk Lembert sutures inserted, followed by closure of the mesentery (E) The necrotic intussuscepted segment (F) sloughs into the intestine.

end. The circular margin of normal bowel tissue is approximated by a single layer of interrupted Lembert silk sutures (Fig 8) The intussusception sloughs and bowel continuity is reestablished. This method can also be used for short segments of necrotic or gangrenous small intestines. A segment of small intestine greater than 7.5 cm. (3 inches) in length which contains numerous perforations should be resected, followed by end-to-end anastomosis Our choice of technic in most small and large bowel resections is the closed method over a Rankin clamp using an inner row of continuous chromic catgut and an outer row of interrupted silk figure of eight sutures However a continuous

silk suture for each half of the circumference may be used on the small bowel It is hazardous to complete a continuous suture around the circumference of the intestinal tract for fear of the pursestring effect Extensive perforations or lacerations of the terminal ileum, if extending into the cecum may be more easily and adequately corrected by resection of the terminal ileum and a segment of the right colon, followed by end-to-end or end-to-side anastomosis over the Rankin clamp There should be no concern about this closed type of anastomosis using this most practical clamp if the thumb and finger can be approximated through the doughnut ring of the anastomosis, but one must not fail to break gently through the crushed bowel ends which have formed a diaphragm In our experience it has rarely been found necessary to resort to a side to-side anastomosis and an end to-end anastomosis is always favored Exteriorization of damaged small intestine with establishment of a temporary ileostomy has been discarded. Bowel continuity is always reestablished The availability of blood, plasma oxygen, better anesthetics and chemotherapeutic and antibiotic agents has practically made the exteriorization procedure obsolete

If an exteriorization procedure should become necessary under some unusual circumstances it is recommended that a mushroom catheter be secured into the proximal stoma and preparations made to reoperate and establish bowel continuity within the next four to seven days

Injury to the Colon Perforating wounds of the colon are frequently a little more difficult to locate because the entire colon cannot be delivered out of the abdominal cavity and carefully stripped This is particularly true of the hepatic and splenic flexures and the ascending and descending colons A wound of the posterior wall of the colon between the leaves of mesentery may be easily missed and any suspicion of such an injury demands incision of the outer leaf of the mesenteric attachment and rolling the colon medially to permit close visual examination The region of the lower sigmoid and rectosigmoid on the peritoneal floor must be carefully exposed and examined

There is some difference in the management of colon injuries under civilian and military circumstances These remarks refer to civilian practice unless the military policy is stated However it must be remembered that under stress of multiple injuries or numbers injured inadequate personnel or equipment, and lack of experience the military practice may prove to be the safer procedure. In general the military principle is to exteriorize the traumatized segment of colon (Fig. 9) or if a wound of the colon is closed, a proximal colostomy must be established.

Under civilian circumstances and adequate conditions one should proceed with closure of the perforation transversely preferably using an inner row of a continuous Connell type suture of #00 chromic catgut The catgut layer is reinforced by interrupted #000 silk Lembert, mattress or figure of eight sutures A tag of omental fat secured to the area gives added protection Smaller perforations may be closed with a pursestring suture of catgut supported by a pursestring suture of silk or several figure of eight sutures in the transverse direction An adequate bowel lumen exists if the thumb and index finger can be approximated through the site of closure or anastomosis Under inadequate or unusual conditions and usu

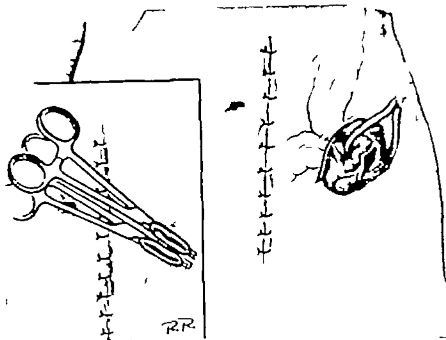


FIG. 9 The segment of perforated colon is delivered through a separate small incision as a colostomy with or without development of a spur by several sutures. This loop is supported by a piece of glass rod or a split tongue depressor covered with a rubber drain. A preferable method is to apply two hemostats after inserting several sutures to approximate the limbs and then excise the traumatized segment. The colon must be mobilized sufficiently to avoid tension on the exteriorized segment.

ally under military conditions the perforated segment is exteriorized as a loop or spur colostomy with the colostomy usually brought out through a separate small incision and without tension (Fig. 9) or if the perforations are closed, a proximal colostomy is established. Placing a mushroom catheter into a perforation and securing the bowel to the anterior abdominal wall, bringing the catheter out through a stab wound, is not recommended. The golden rule for rectal perforations is a colostomy of the sigmoid or transverse colon A colostomy of the transverse colon through a small transverse incision has the advantage in extensive destruction of the lower sigmoid, rectosigmoid, or rectum in facilitating the use of the sigmoid for any later reconstruction of the rectum (Fig 10) If there is marked destruction of a colon segment or an area of multiple perforations exteriorization or preferably a resection and anastomosis is advisable We prefer a closed type of anastomosis using the Rankin clamp technic, and if one is familiar with this technic in elective and routine colon surgery some advantages exist when the bowel has not been properly prepared as is the case in traumatic surgery We always prefer to use an inner row of continuous catgut for each half of the circumference of the colon, supporting this with interrupted figure of eight or mattress silk sutures. With closure of perforations of the entire colon and with resections of the right colon and transverse colon one may depend on nasointestinal suction for decompression. With resections of the left colon, sigmoid, and rectum, it is safer to estab-

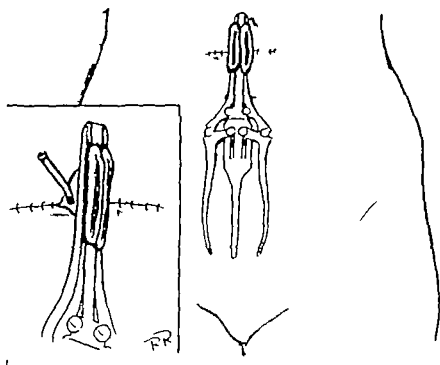


FIG. 10 A small transverse incision through all layers is made for a colostomy of the transverse colon. The falciform ligament is ligated and divided. After excising a small segment of the greater omentum, a few lesser vessels of the transverse mesocolon are clamped, divided, and ligated to permit delivery of the colon. Several catgut sutures approximate the two limbs to hold surfaces in contact. A Rankin clamp or two small crushing clamps are applied. The colon distal to the clamp is divided. For immediate decompression a catheter is pursestringed into the proximal limb. Otherwise the proximal limb may be opened after seventy-two hours and the clamp on the distal limb prevents retraction of the spur

lish a supplementary cecostomy for decompression and not depend upon the uncomfortable nasogastric or nasointestinal tube with suction. A cecostomy has several advantages in that the nasogastric tube can usually be omitted, and if properly done it almost always closes without further operative intervention. One should use a #32 or larger mushroom catheter After applying a soft bladed, curved intestinal clamp to the caput cecum, a catgut pursestring suture is inserted, the cecum is opened, and the tube which had previously been inserted through an abdominal wall stab wound incision far to the right is placed in the cecum and secured by the pursestring suture The cecal wall is imbricated around the tube by interrupted catgut sutures and the cecum is secured to the parietal peritoneum by several sutures (Fig 11) This tube is irrigated night and morning with 30 to 60 cc. (1 to 2 ounces) of warm water Usually suction is not used, or if it is used very little pressure is exerted in order to prevent mucosal blocking of the tube A colostomy of the transverse colon diverts all fecal flow from the site of injury or anastomosis and is particularly indicated where there is apprehension about the security of the anastomosis or proper primary healing taking place or where there is a possibility that a perforation

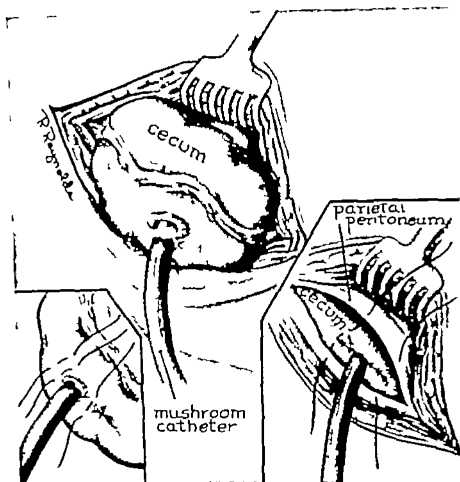


FIG. 11 A cecostomy may be established through a small McBurney incision or through a stab wound supplementing an operative incision. A number 32 or larger mushroom catheter is inserted and secured with a pursestring of catgut. The area is imbricated with several interrupted catgut sutures and the cecum secured to the parietal peritoneum.

may have been overlooked or not located because of its inaccessible position.

Closure of a colostomy may be accomplished by crushing the spur followed by closure or by resection and end-to-end anastomosis over the Rankin clamp With preparation of the intestinal tract by oral antibacterial agents resection of the small colostomy segment is now the preferable method. Frequently multiple spur crushings are necessary which means more hospital days with more expense and loss of time for the patient. With the use of antibiotics and chemotherapeutic agents in the preparation of the bowel and their use postoperatively the morbidity and mortality for closure of the colostomy by resection is no greater than by the older method of spur crushing and closure

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RUSSELL S FOWLER, M D

27

Management of Generalized Peritonitis of Exact Unknown Etiology

IN the course of treating surgical patients with acute abdominal conditions, the exact underlying cause for the patient's symptoms at times cannot be definitely established. This situation is especially true when an individual presents a clinical picture of generalized peritonitis.

Generalized peritonitis of exact unknown etiology is usually secondary to gastrointestinal lesions in the male and to pelvic lesions in the female It runs a rapid course If treatment is delayed the condition becomes desperate through absorption of toxic products, the elimination of which is the rational treatment.

Treatment should be initiated at once The control of mixed infections is accomplished with penicillin (500 000 units intramuscularly followed by 300 000 units intramuscularly q 3 h) and streptomycin together with aureomycin or chloromycetin. Terramycin intravenously may be used in place of penicillin (see antibiotic treatment) Bed rest in the elevated head and trunk position (semisitting, using Gatch bed) to slow down the intraperitoneal wave of the diaphragm and so slow absorption and favor localization. Nothing is given by mouth. The long perforated Wangensteen tube should be inserted to keep the stomach empty and to aid in small-intestinal clearance If great distention or obstruction results one should use the Miller Abbott tube (see intestinal obstruction) A rectal tube is often efficacious Intravenous glucose solution and isotonic saline solution (with potassium chloride if potassium deficiency is present) in amounts in accordance with cardiac and renal function and dehydration are given Amino acids are valuable to maintain fluid balance and nourishment (see Fluid and Electrolyte Balance)

A complete history and physical examination with a flat x-ray plate of the abdomen, urinalysis, and complete blood count will frequently point to a tentative diagnosis as to the origin of the infection, whether from within or without the gastrointestinal tract, [illegible] abdominal cavity pelvic organs, or [illegible] an infection from another part of the body (pneumonia, influenza) or [illegible] of some other disease (typhoid [illegible] losis) Demerol and morph[illegible] trol pain should be given [illegible] a complete study of the [illegible] cases often tax one's diagn[illegible]

Operation combined wi[illegible] apy is the treatment of [illegible]

tonitis of unknown etiology Chemotherapy is essential but must not take the place of operation except in cases too ill for the latter

Operation is performed as soon as the patient s condition permits Time-proven surgical principles must not be forgotten. Incise carefully to avoid intestinal injury over the site of the tentatively diagnosed lesion.

If no diagnosis has been made use an upper or lower right rectus or midline incision according to maximum muscular tension distention, or tenderness Note if free gas is present and/or its odor Gently raise the abdominal wall, note the character of the fluid, whether serous bile blood, or pus whether food particles or intestinal contents are present, and whether the intestine is glistening or has lost its luster one should note if the intestine is thin or thick walled dilated or collapsed spastic studded with implants or has fat necrosis in the omentum all of which give *hints as to the lesion and facilitate ex*ploration. Culture the fluid for possible later change in antibiotic therapy Use suction *paripassu* with exploration a *gush of fluid may lead to the lesion* Extend the incision or make an additional one as needed to deal with the findings If an abscess is present use great care in suction If no cause for the peritonitis is found, suction dry and tube drain the pelvis One should drain abscesses Continue suction until entire peritoneal cavity and pelvis is free of fluid. Gently separate actual obstructive loops Multiple enterostomies are useless they only empty individual loops and the paresis and obstruction continue

If the general condition of the patient does not allow an operation one should continue the measures already outlined till operation can be done or as sometimes happens may no longer be necessary With modern anesthesia, blood transfusion, and antibiotics it is marvelous what miracles occur

Postoperative Treatment Continue preoperative regimen supplying vitamin deficiencies and supportive measures as the indications arise correcting the derangements in physiologic chemistry Collections of fluid may require later drainage As the patient s condition improves, turn to postlaparotomy treatment.

Preoperative preparation antibiotics blood transfusion, modern anesthesia and postoperative treatment have made practically all operative procedures safe in hands technically skilled. Preventive *treatment of generalized peritonitis* is the early treatment of those lesions which from their life story may result in peritonitis

Addenda The antibiotics which are efficacious in the treatment of peritonitis are penicillin streptomycin or dihydrostreptomycin aureomycin and terramycin.

Cortisone is advocated by some investigators It is given to patients with overwhelming infections The basis for the administration of this drug is the belief that cortisone increases tissue resistance to infections

CHARLES B RIPSTEIN, M D

28

The Management of Acute Gastrointestinal Hemorrhage

ACUTE gastrointestinal hemorrhage may be manifested by hematemesis melena, or both. As a rule, hematemesis indicates bleeding from the esophagus or stomach melena, bleeding from the large or small bowel the combination of both is characteristic of duodenal or gastric lesions Gastrointestinal bleeding always constitutes an emergency and it is essential to plan a rational approach to diagnosis and treatment.

The most important considerations in any case are

1 Treatment of shock blood replacement.
2 Control of bleeding by local measures
3 Diagnosis
4 Definitive therapy to correct the cause of the bleeding

Blood Replacement Theoretically the blood loss should be replaced in equivalent volume but it is often difficult to estimate blood volume as a practical procedure It is usually adequate to give sufficient blood to maintain the blood pressure at 100 to 120 mm. Hg and to restore the hemoglobin level to eighty per cent. The only danger from excessive transfusion is that of overloading the circulation and causing cardiac failure This is a real hazard in elderly patients The fear of precipitating further bleeding by raising the blood pressure is greatly exaggerated. In our experience more patients have been lost from inadequate transfusion than from any other single cause It is also important to realize that following a massive hemorrhage there may be a secondary drop in hemoglobin and it is essential to correct this so that if further bleeding occurs the patient is better prepared for it.

Measures to control bleeding must proceed hand in hand with blood replacement. Despite the favorable reports of forced feeding we feel that initially it is better to keep the stomach empty and give nothing by mouth. A soft rubber nasal tube is passed for several reasons first because constant suction keeps gastric acid away from the bleeding area and prevents digestion of the clot. Secondly the acute dilatation of the stomach which so often follows hemorrhage is prevented and we believe that the maintenance of muscular tone in the gastric wall may be an important factor in the arrest of bleeding Thirdly observation of the gastric aspiration gives an indication as to whether active bleed-

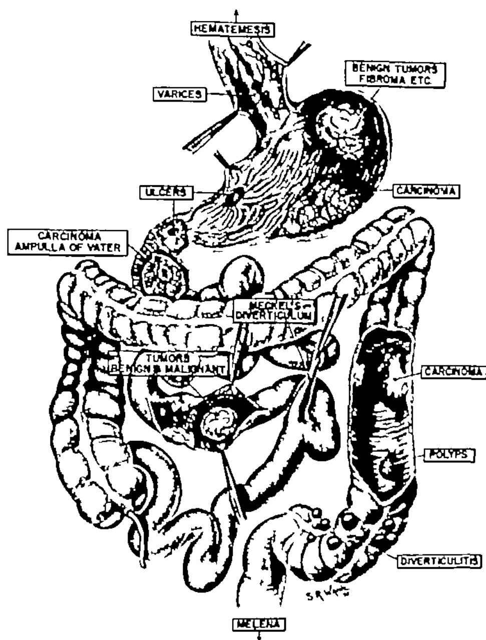


FIG. 1 Common causes of gastrointestinal hemorrhage.

ing is continuing Finally the tube is useful for maintaining a constant intragastric drip which neutralizes acid and helps maintain nutrition. Protein hydrolysates, which are amphoteric and carry a high caloric value have proved to be most useful The fear that a soft tube will aggravate bleeding has not been borne out by experience

Several authors have recommended the local use of thromboplastic substances. We have not been convinced of their value Other measures of importance are the correction of prothrom-

bin deficiency and the determination of any existing blood dyscrasia More specific measures to control gastrointestinal bleeding can best be considered under the local areas involved

It is often difficult to make an exact diagnosis of the site of bleeding on clinical grounds alone and emergency x ray examination of the gastrointestinal tract has been recommended in cases of hemorrhage In some instances an exact diagnosis can be established by this means and such knowledge facilitates the further management of the case In other instances, examination is not satisfactory and the manipulation is harmful to the patient. We have not considered emergency barium studies to be of sufficient value to warrant their routine use In our own series, a satisfactory examination was obtained in sixty per cent of the cases and a positive diagnosis established in only half of these

When surgical exploration is undertaken without an exact diagnosis an orderly inspection of the abdominal viscera is essential to determine the site of the hemorrhage If the bleeding is from esophageal varices the liver is usually shrunken and irregular the spleen enlarged, and the abdominal veins congested and tense If these signs are absent, the source of bleeding is elsewhere in the gastrointestinal tract. Palpation and inspection of the stomach, duodenum and bowel may reveal the lesion but if no bleeding site is found the mucosal surfaces of these organs must be inspected We have routinely used a sterile sigmoidoscope which can be inserted through small openings in the intestinal wall. On several occasions, minute lesions such as hemangiomata have been found by this method. The area to be inspected can be roughly determined by the level of blood in the intestine Since blood seldom passes proximal to any great extent, the source of bleeding is usually cephalad to the upper level of the blood within the intestine Thus if blood is found up to the ligament of Treitz the likely source is the stomach or duodenum

The biliary tract should be carefully examined if no other source of bleeding is found On rare occasions bleeding from lesions of the gallbladder and bile ducts may be manifested as melena. Occasionally even after thorough examination no source of bleeding can be found and the surgeon is then faced with a perplexing problem If the blood extends up to the ligament of Treitz it has been our policy to perform a subtotal gastrectomy The basis for this procedure is that in these cases, the most probable lesion is a small fissure-like ulcer which cannot be palpated or visualized and we have often had the satisfaction of finding such a lesion in the resected specimen. However cases do occur in which no bleeding source can be found even at autopsy and these still remain an enigma

BLEEDING FROM THE ESOPHAGUS

Esophageal varices are a common source of gastrointestinal hemorrhage These dilated veins in the submucosa of the lower esophagus represent a compensatory collateral circulation which develops in portal hypertension. The common cause is intrahepatic obstruction due to cirrhosis of the liver but extrahepatic obstruction may occur due to lesions in the splenic or portal veins These varices tend to bleed readily because they are thin-walled and are exposed to the mechanical trauma of food, acid regurgitation, and diaphragmatic movement. This tendency may be ag-

gravated by hypoprothrombinemia and thrombocytopenia which exist as manifestations of the underlying liver disease

The clinical pattern of esophageal bleeding is often characteristic The initial hematemesis is not vomited but bright red blood wells up into the mouth without retching This is followed by nausea and vomiting of dark clotted blood

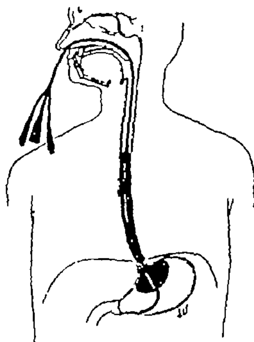


FIG. 2. Esophageal tampon for control of bleeding of esophageal varices.

Other manifestations of cirrhosis such as a hard nodular liver spider nevi, or splenomegaly may or may not be present. At times it is extremely difficult to make an accurate diagnosis and we have adopted the routine of doing an emergency thymol turbidity and BSP retention test in all cases of massive gastrointestinal hemorrhage If these tests are within normal limits, cirrhosis of the liver can usually be excluded as a cause of bleeding. It must be pointed out that shock can cause BSP retention even with a normal liver b turbidity is rarely affected

Emergency operation i cated for hemorrhage fr varices The bleeding is walled veins and they can compressed by an intraes pon. An esophageal ball place for twenty four t hours and this usually suf the bleeding. Some author mended emergency esophag or splenorenal venous an the treatment of uncontro rhage from esophageal va are formidable procedures tality rates are high. Howe ing continues despite tam procedures may be justified

BLEEDING FROM THE AND DUODEN

The common causes of orrhage are peptic ulcer an Less frequently benign tu mata, or chronic gastritis sponsible for massive bleed adage that gross hemorrh nostic of a benign ulcerati discarded Carcinoma of not infrequently manifest bleeding In any case, no sion of the stomach can sa sidered as benign without proof and we have adopte of treating all gastric ulce as soon as bleeding has cea patient has been restored nitrogen balance

If bleeding continues despi tive measures, operation sh ried out before the patient exsanguinated Forty-eight longest safe period permiss servation and a decision ca

ways be made within twenty four hours The most dangerous type of case is that in which bleeding ceases rapidly and resumes within a short time We feel that recurrent hemorrhage is an urgent indication for surgery and delay may be fatal This is especially true in older individuals with sclerotic vessels.

Repeated episodes of hemorrhage produce irreversible changes in the liver kidneys, and heart and lead to adrenal exhaustion Even though the blood loss is replaced these patients come to surgery in a depleted state and do not tolerate operation well We have rarely made a mistake by operating early in gastric hemorrhage but too often we have had cause to regret delay Bleeding is a common complication of duodenal ulcer occurring in ten to twenty per cent of patients with this condition. The hemorrhage usually ceases spontaneously or with conservative management but it is most important to establish the indications for surgical intervention.

A great deal of confusion has arisen in the past because in various reported series the definition of massive hemorrhage has varied from a tarry stool to total exsanguination We have adopted the arbitrary criteria of a fall in hemoglobin to a level below fifty per cent and/or the production of a shock-like state with a fall in blood pressure and a rapid pulse. Patients falling into this category are seen by the surgeon and carefully followed while on a medical regime The primary aim is to allow the bleeding to cease and then to make a definitive diagnosis and treat the condition as indicated. However such a course is not always feasible and the following indications for emergency operation are recognized

1 Failure to control bleeding within twenty four hours This may be manifested by rapid pulse, low blood pressure or low hemoglobin level

2. Recurrence of bleeding after cessation.

3 Massive hemorrhage producing a shock-like state in individuals over fifty

4 Previous episodes of bleeding or the presence of a known chronic ulcer

In case of doubt it is preferable to operate early rather than to wait until the patient has become exhausted from continued blood loss.

The operation of choice for massive hemorrhage from the stomach or duodenum is subtotal gastric resection with removal of the bleeding lesion. Attempts to control hemorrhage by ligation of vessels usually end in failure In recent years we have seen several cases in which fatal recurrent bleeding has occurred from an ulcer left *in situ* when gastrectomy was performed and we have become convinced that every effort must be made to remove the ulcer in these cases If a deep crater is left penetrating the pancreas the vessels in its base should be ligated with silk sutures and the crater packed with gelfoam.

BLEEDING FROM THE SMALL BOWEL

Intestinal bleeding is difficult to localize and a correct diagnosis is usually made by exploration In children, the common causes are polyps, intussusception, duplication, or Meckel's diverticulum in adults regional enteritis or tumors In our experience smooth muscle tumors have been a fairly frequent cause of intestinal bleeding. The association of crampy abdominal pain and diarrhea with massive hemorrhage should always arouse suspicion of a small-bowel le-

sion In most cases, bleeding will cease spontaneously with conservative management but if it does not stop quickly or if it recurs exploratory laparotomy is indicated to discover and treat the cause of the hemorrhage Any patient who has recurrent episodes of gastrointestinal bleeding should be explored even though repeated x ray examinations are negative.

BLEEDING FROM THE COLON

Hemorrhage from the large bowel is usually a brighter red in color than that from any other site in the gastrointestinal tract The blood may be mixed with the stool and often contains fresh clots

Hemorrhoids are the commonest cause of rectal bleeding but the presence of hemorrhoids does not mean that they are the source of hemorrhage in any given case. Other more serious lesions such as polyps or carcinoma, must be excluded by careful examination with the sigmoidoscope and by barium enema

Benign ulcerating lesions and diverticulitis may also give rise to massive bleeding from the rectum

In all cases of melena, sigmoidoscopic examination should be carried out as soon as possible In many instances the bleeding point can be visualized and the hemorrhage controlled with the coagulating current. If blood is seen coming from above it is obvious that a high lesion is the source of the hemorrhage and the exact diagnosis must be established by barium enema.

Bleeding from the colon usually responds to conservative measures and *definitive therapy can best be carried* out later with the bowel prepared by antibiotics In rare instances emergency colon resection is necessary to control hemorrhage especially in acute ulcerative colitis.

29

Gastric Dilatation

ACUTE GASTRIC DILATATION

ACUTE gastric dilatation is a very serious condition with a dramatically sudden onset. Fortunately it is becoming of only historic interest in many of the larger centers but is still a dangerous condition in smaller centers and in situations where modern equipment is not immediately available

The stomach rapidly fills with gas and may almost completely fill the abdomen accompanied by a tremendous outpouring of juices which rapidly fill the distended stomach with fluid. It invariably occurs following some form of physical stress usually an abdominal operation on a viscus other than the stomach, but it can occur after labor paracentesis of the abdomen, spinal injuries, particularly if recumbent and associated with the application of plaster of paris jackets, and may also follow such simple procedures as ureteral catheterization.

The actual etiological factor is quite unknown and the exact mechanism of its occurrence is also not clear It is almost certainly of nervous origin and due to the reciprocal innervation of vagus and sympathetic through the celiac plexus Stimulation of the sympathetic causes increased tonus of both the pyloric sphincter and the cardia with inhibition of fibers of the gastric musculature, resulting in closure of both ends of the stomach and inhibition of its musculature

It is more difficult to explain the subsequent sequence of events The situation becomes alarming so rapidly Shock becomes so apparent and death intervenes with such promptitude that something more fundamental than mere gastric dilatation must be involved.

The original concept that the condition was due to pressure of the superior mesenteric vessels upon the third part of the duodenum has now largely been abandoned It is probably quite true that once the condition has become established, with a patient in the upright position or in those with lordosis, that aggravation of the condition by purely physical drag of the intestines is possible and probably inevitable but that it is a primary factor in its development, is difficult to believe Anatomically there is always considerable freedom for the finger to pass under the superior mesenteric artery even in the most advanced or fatal cases The role of the superior mesenteric artery is probably that of aggravation of the established case

The clinical picture can scarcely be missed The sudden onset associated with thin feeble pulse anxious expression, distended upper abdomen, hiccough head perspiration and rapid deterioration is a typical picture Almost immediately a spill-over type of vomiting develops much as in ileus constant and usually unsuccessful attempts at eructation with spill-over of brownish fluid which may stain or burn the lips or chin is characteristic Thirst becomes intolerable deterioration unbelievably rapid, dehydration hypochloremia, mounting blood urea and nonprotein nitrogen are rapid and ominous signposts The urine becomes scanty albuminous and highly concentrated. If the condition is unrelieved, it may progress to death in a matter of hours as compared to the day or so required to produce the same status in intestinal ileus with which it might be confused.

Attempts to bring up the gas are usually unsuccessful but if not, it escapes with a loud report, accompanied by large quantities of fluids subsidence of the distention in the upper abdomen, and improvement in the condition with rapid relapse Gas recollects rapidly but the brownish fluid once escaped does not re-collect to the same extent and ceases largely to be a problem.

Aerophagia is a concomitant feature of most of these cases and a rumination-like complex develops with a one way transit of air down the esophagus into the stomach. There are however two distinct types of case with respect to aerophagia The true gastric dilatation distends with a gas which is largely nitrogen and CO but the areophagic type which, if primary is not a true gastric dilatation case produces a gas which resembles normal air and is not associated with gross gastric succorrhea Probably all these cases of true acute dilation are not aerophagics to begin with but in the constant struggle to eructate gas they become areophagics even in the stage immediately succeeding the relief of distention by mechanical means Aerophagia is such a common thing and acute gastric dilatation so uncommon that the former probably only complicates the latter and is in no way an etiological factor

The great accumulation of secretion is difficult to explain and far exceeds even the large known quantity of circulating fluid into the upper reaches of the bowel and absorption from its lower reaches It is highly probable that the abnormally weak or semiparetic muscle is unable to expel gastric contents against what is probably only a normal resistance mechanism in the sphincter It is the failure of reabsorption of this normal vast circulating fluid from the upper reaches—by the lower reaches of the bowel that creates the dehydration and alkalosis that develops with these cases The fall of the blood chlorides roughly parallels the rise of the CO_2 combining power in these cases and in conjunction with the rising blood protein nitrogen may be of serious and valuable prognostic importance

That the condition is not vagal in origin would seem to be made clear by the fact that the small bowel peristalsis is not interfered with and the hypersecretion of the stomach is in direct antipathy to the well known postvagotomy inhibition of secretion and flaccid paresis of the stomach

Attempts to explain the development of acute gastric dilation by exposure to

cooling air on the operating table are not borne out by facts After any opening of the abdomen peristalsis is temporarily suspended, accounting for the discomfort and flatulence of the second and third postoperative day This is, however of slow development and intestinal as opposed to rapid development and confined to the stomach or at least to stomach and duodenum

Anesthesia of almost all types have been blamed for its development. Series of cases are on record attributing it to the use of ether anesthesia other series are equally certain that it is due to spinal anesthesia That anesthesia of any kind has anything to do with it is unsupported by acceptable facts or proof

The most serious and dramatic case of acute dilatation that I have seen in recent years occurred on the operating table during the exploration of a suspected lesion of the ampulla of Vater Anesthesia was by intratracheal administration and a gastric syphon drainage tube was down the esophagus and into the stomach, but was clamped off The stomach became enormously distended in a matter of minutes and was released by retrograde passage of a catheter through the opened duodenum, through the pylorus into the stomach, and escaped with a loud whistle Within minutes it recurred and could only have developed by dialysis from the blood in the vessels of the gastric wall and could not have been swallowed. The suction tube was unclamped, aspiration undertaken, and the distention did not recur Aerophagia was in this case quite impossible

It is highly probable that in all severe cases, several etiological factors are operative hyperactive sympathetic response—partial vagal paresis, mechanical factors as a late and secondary aggravation due to poor postoperative posture or any combination of the above acting together with exposure, trauma anesthesia, or other unexplained or unsuspected chemical or nervous phenomena. Recognition of this condition is essential All neglected, unrecognized and untreated cases end with death.

Treatment of Acute Gastric Dilatation Merely turning the patient on the face or in the full prone position will frequently lead to an explosive report with the vomiting of huge quantities of brownish fluid with immediate relief Such relief lent credence to the mechanical or compressive theory of its development. The two greatest factors leading to the disappearance of this serious condition from medical practice has been early ambulation and gastric syphon drainage Almost all cases nowadays who become at all distended or who threaten to do so have gastric syphon drainage installed as a prophylactic measure and this has reduced the condition to one which the younger generation rarely sees.

Treatment of the Established Case This requires something more than merely evacuating the stomach of gas and fluid. The serious electrolytic imbalance must be restored, dehydration overcome, and full scale restitution and repletion carried out forthwith. Continuous gastric syphon drainage with intravenous saline, glucose, and protein hydrolysates checked by clinical observation and laboratory methods of blood protein, hematocrit, blood chlorides, blood N.P.N., urine volume, and dilution. Once such a case has been relieved and restored, I have not known it to recur

While death is inevitable in these cases if not recognized, relieved, and

repletion carried out, there should be no deaths in this serious and unusual condition in these times

Approximately one third of all cases of duodenal ulcer show some degree of gastric retention frequently from spasm or associated edema. Many other conditions have an associated pylorospasm such as gastric ulcer or gallbladder dis-

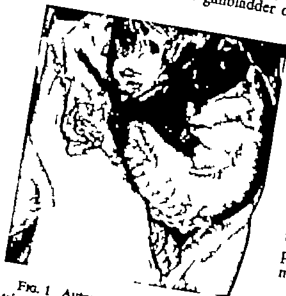


FIG. 1 Autopsy specimen of acute gastric dilatation following cerebral vascular accident. Small bowel does not share in the distention.

ease but these are not usually associated with much gastric dilatation However actual blocks with developing dilatation may result from such lesions as carcinoma of pyloric antrum of stomach hypertrophic pyloric stenosis leiomyoma prolapsing polypi or prolapsing redundant gastric mucosa. Even foreign bodies may in time lead to hypertrophic dilatation of the stomach

GASTRIC DILATATION IN HYPERTROPHIC PYLORIC STENOSIS

If one accepts the dictum that the power to hypertrophy under the stress of overactivity is a property of all muscle then the obstructing lesion in this condition must be of nervous origin and due to hyperactivity of the sympathetic keeping the pylorus tightly closed and a resultant hypertrophy of antral musculature immediately proximal to it in attempt to overcome such closure The condition usually develops about three weeks after birth in boy babies with a normal background and no congenital taint is traceable in the vast majority of cases All such cases develop gastric dilatation accompanied by vomiting of a projectile character and with resultant dehydration and inanition. This gastric dilatation may be readily visible if the abdomen of the child be exposed after a nursing, and visible peristaltic waves may be seen passing over the stomach. Occasionally a peanut sized and shaped tumor may be visible or palpable at the pyloric end of the stomach, but by no means always

Gastric dilatation in hypertrophic stenosis may be readily confirmed by x ray examination It is a straight physical block and a high degree of retention may be observed. As long as an hour and a half may elapse before any barium at all leaves the stomach and then but the merest trickle This dilatation of the stomach is not merely a passive stretching as from three to five peristaltic waves may be visible radiologically at the one time In cases where the duration is only of a few weeks there is not usually much time given for the stomach to hypertrophy but if the diagnosis has been delayed in a case presenting considerably less than complete closure the stomach wall may thicken remarkably from muscular hypertrophy If in cases of projectile vomiting where hypertrophic pyloric stenosis is suspected the stomach would appear to empty readily with but tempo-

rary spasm type of retention then consideration should be given to the possibility of intracranial disease

Surgically all that is required is that the obstruction should be overcome by some such operation as Ramstedt's procedure after suitable measures of repletion If the child has been seen late The gastric dilatation and muscular hypertrophy will subside as a matter of course These cases are notoriously susceptible to wound disruption and should be closed with some such nonabsorbable suture material as fine stainless steel wire, either plain or preferably multiple twist, but the use of steel in no way reduces the necessity for the overcoming of hypoproteinemic states to which these children are prone by the very nature of their illness



Fig. 2. Air pattern of grossly dilated stomach. Congenital hypertrophic pyloric stenosis.

GASTRIC DILATATION DUE TO CICATRIX OF A PYLORIC OR DUODENAL ULCER

This is by far the commonest cause of pyloric stenosis with subsequent gastric dilatation. The stenosis does not need to be complete for gastric dilatation to reach an advanced stage but the developing obstruction and subsequent dilatation may progress to a remarkable degree with relative quiescence. The supervention of complete obstruction on such a developing case is usually due to edema of the pylorus rather than complete cicatricial occlusion

Vomiting is unusual in duodenal ulcer but becomes increasingly common as obstruction and dilatation progress Patients do not usually complain at this stage of the pain usually attributed to ulcer but rather of a sense of fulness a bloating and a sense of nausea which is often aggravated rather than relieved by food, resembling in that way the symptoms produced by prolapsing gas-

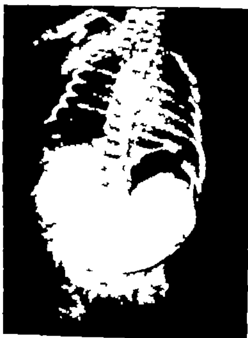


Fig. 3 Gross gastric dilatation of stomach in congenital hypertrophic pyloric stenosis. Barium filled. Same case as Fig. 2.

tric mucosa These people at this stage usually experience relief from vomiting, frequently to the extent that it becomes self induced by introducing the finger down the throat. Ulcer patients as a rule have a good appetite but are afraid to eat because of the subsequent pain but at the stage of obstruction of the pylorus pain is not a factor Appetite is lost or very poor eructations of foul gas are common, and the vomitus may contain some easily recognizable foods that have been ingested perhaps days before



FIG. 4 Grossly dilated stomach with cicatrizing duodenal ulcer perforating lesser curve benign ulcer achlorhydria unresponsive to histamine

These people frequently have an achlorhydria or very low acid responsive to histamine or insulin in the younger group but frequently unresponsive to histamine or other acid stimulant in the older age group The stomach may contain many products of putrefaction Total acidity may be high as a result and yet free hydrochloric may be absent or very low Yeast cells and food debris constitute the residuum. These people become emaciated and, as obstruction becomes complete and the stomach becomes enormously dilated, there develops or supervenes a serious deficiency state due to acute depletion supervening upon a chronic starvation state

Such an acute stage of dilatation is fraught with serious consequences as rapidly hypoproteinemic states develop together with dehydration rapid wasting, hypochloremia avitaminosis and the familiar picture of an acute depletion state.



FIG. 5 Gross gastric dilatation in prepyloric carcinoma

The clinical picture at this stage is unmistakable The vomiting, hollow cheeks anxiety restlessness and paresthesia testify to the seriousness of his depletion. The stomach may be seen in thin

individuals to be grossly distended dull to percussion, succussion sounds may be heard, the blood urea and blood non protein-nitrogen are climbing, the CO_2 combining power is grossly disturbed Dehydration may confuse the blood picture, hematocrit, and blood chloride readings Gastric tetany with positive Chvostek signs and carpopedal spasm and marked avitaminosis develops and, withal, if such a patient is seen at this stage of advanced gastric dilatation and pyloric occlusion he is definitely in no condition to withstand any surgical assault. Home remedies in the nature of alkaline therapeusis can be fatal in this stage. Roentgenograms of such a stomach reveal enormous dilatation, the stomach almost filling the abdomen with a high or total degree of gastric retention

While the case must become surgical restitution and repletion are of much more urgent importance than surgery Intravenous saline and glucose suitably spaced and in quantities safe for their age group are immediately and slowly given The stomach should be washed out through a large size gastric lavage tube and a gastric syphon drainage tube passed and connected to the suction bottle The patient should be encouraged to drink past his tube and allow it to return through the suction. A special nurse should be assigned to see that the suction apparatus is at all times kept open and operating There are few things more useless than a suction which will not suck.

Complete repletion by parenteral therapy should be continued over a period of days while the suction is kept working. Ultimately the edema in the stomach wall will be so reduced through correction of the hypoproteinemia and the release of tension within the gastric walls that tonus will be in part restored and some patency of the pylorus developed

There can be no substitute for fluids and foodstuffs absorbed into the blood stream from the alimentary tract. Valuable as parenteral administration may be in an emergency it should be remembered that it is emergent medication and normal alimentation should be restored as rapidly as possible

The degree to which patency and gastric emptying has been restored can be easily determined without barium and x rays, by a simple pyloric balance test. The stomach is aspirated quite empty through the gastric syphon drainage tube and 200 cc. of fluid introduced into the stomach. After two hours the stomach contents are aspirated, if 200 cc. or more are returned there is still a high degree of gastric retention If there are 80 cc. or thereabouts recovered there is very moderate retention, and under that amount is considered to be normal. The response to this test will often give a good clue to the amount of food which can be given by mouth and whether the suction tube is still essential

These cases are of course, surgical, but when should they be operated upon and what should be done?

There can be no set rule with respect to time, as each case is a law unto itself Restitution should be complete and no surgery should be undertaken until the completeness of preoperative restitution is beyond question. Apart wholly from the laboratory criteria by which this may be judged, the clinical assessment must bear witness to the testament of laboratory conclusions Restoration should be by alimentation

George E Moore, M D

30

Emergency Surgery for Acute Intestinal Obstruction

Introduction There have been numerous articles on the subject of bowel obstruction in medical literature as well as several excellent monographs. Included among the latter is the source book "Intestinal Obstructions" by Wangensteen [11] However despite the excellent studies on the etiology diagnosis and treatment of intestinal obstruction and general interest in this field, both clinical and experimental, there continues to be a discouragingly high mortality rate The advanced age and debility of many patients succumbing to the effects of intestinal obstruction is not a valid excuse for an indifferent attitude toward this problem Without fear of contraindication, it can be said that the continued high mortality rate from intestinal obstruction is the result of the failure of recognition and secondly procrastination in initiating definitive treatment.

It must be emphasized that bowel obstruction, as is true of most biologic phenomena cannot be rigidly categorized in addition the clinical status of bowel obstruction is not static For example a simple obstruction which persists until the intramural blood supply is impaired by increased distention may become, in effect a strangulating obstruction.

History Probably the most important single item in attaining a successful outcome from this catastrophe is the obtaining of an accurate, careful *history particularly of the character and time of the onset of symptoms*, correlated with the subsequent development of physical signs as revealed by the initial physical examination As soon as the patient is seen an attempt must be made to get from the coherent patient, or a relative the exact time and nature of the onset of the illness Most significant is the degree of severity of abdominal pain, since by careful consideration of the *suddenness of onset* and the development of culminating severe, cramp-like pains can a simple bowel obstruction be best differentiated from a strangulating one

In early small-bowel obstruction the pain is characteristically cramp-like and coincides with overactive peristaltic waves, producing a sudden increasingly severe colicky pain which may last from one to three minutes and then suddenly *disappear leaving the patient weak and* sweaty only to have the entire sequence recur again at intervals ranging from a

few to as long as twenty minutes It is most important that the admitting physician stay with the patient for at least ten to even thirty mintues in order to catch the occurrence of a typical borborygmus The auscultation of such an occurrence coincident with the onset of a severe crampy pain characterized by the patient drawing up the knees and writhing in pain, is enough to establish a clear cut diagnosis of intestinal obstruction Certainly a history indicating the rapid development of increasingly severe crampy pains which have become more or less generalized and accompanied by a shock-like condition of the patient indicates a strangulating obstruction demanding immediate positive, complete therapy

Many text books have suggested that an indication of bowel obstruction is the absence of the passage of flatus or of fecal material. This, however is not substantiated by clinical experience. Not uncommonly patients are seen with a complete strangulating obstruction and yet they have passed small amounts of gas which was previously in their colon, or a small amount of fecal material. This "red herring" has in many instances resulted in a fatal delay in initiating definitive therapy

The history of vomiting, as indicated previously is important, but not as often characteristic of bowel obstruction unless stercoraceous in nature. Vomiting is more or less a regular accompaniment of intestinal obstruction and is generally related in the time of onset to the level of intestinal obstruction. Vomiting occurring immediately after the onset of severe crampy pains often indicates an obstruction of the upper portion of the intestine In contrast, fecal vomiting occurring some four to ten hours after the onset of crampy pain is more indicative of an ileal obstruction The appearance of fecal vomiting is of course most indicative of a small bowel obstruction however in the presence of an incompetent cecal valve, it may also occur with a large-bowel obstruction particularly of the right colon

In obtaining the history many items proposed by the patient to explain his present condition must be judiciously evaluated and in many instances rejected as the cause of the present illness Not infrequently the patient or his anxious family will ascribe the present disease to overeating or indulgence in some special food or drink. In other cases an unusual physical exertion is blamed for the onset of his symptoms In most instances the clinical picture of early collapse and profound peristaltic activity accompanied by diarrhea which commonly follows acute food poisoning is easily distinguished

The magnitude of distention is often proposed as indicating the presence of bowel obstruction however in early bowel obstruction, distention is often not present. Moreover obstruction of the upper portion of the small bowel is rarely accompanied by distention unless a closed-loop obstruction is present. With the onset of vomiting, no distention may develop However more commonly low intestinal obstruction is accompanied sequentially with a lesser degree of vomiting and a gradual increase in abdominal distention. Finally late in the course of obstruction, the abdominal distention may become severe with a subsidence of borborygmi and intestinal cramps, *indicating that the* obstruction has been *present for a long* time and probably *peritonitis has ensued*

PAST HISTORY A careful note should be made of the patient s past health particularly of previous attacks of in-

testinal pain. If for example there have been several instances of attacks of a similar nature in childhood the possibility of Meckel's diverticulum should not be overlooked A history of laparotomy either in the recent or distant past is suggestive of the presence of an adhesive band as the etiological agent of obstruction Such a finding may also be of prognostic significance since *adhesive bands are the most frequent cause of simple bowel obstruction*

Similarly *the single commonest agent producing incarcerated and strangulating bowel obstructions is an external hernia* Careful questioning to elucidate the presence of a hernia and recent difficulty in reducing it is mandatory A history of cardiovascular accidents may suggest the presence of a mesenteric thrombosis or emboli More infrequently the history of recent biliary tract disease perhaps accompanied by jaundice and pain which finally subsided spontaneously may suggest the rare instance of gallstone obstruction of the small bowel

Certainly one must be careful in evaluating those patients with a history of illness and repeated attacks of intestinal obstruction treated by hospitalization with successful recovery However the ready acceptance in the last few years of various neuroses as the etiological agents of obscure abdominal pains which were not otherwise diagnosed has resulted in a serious delay of treatment. In this clinic the occurrence of a good history and the physical signs of bowel obstruction unaccompanied by definite organic pathology has been rare

Finally it must be reiterated that bowel obstruction can and often is an *early* complication of abdominal surgery and less frequently of accidents involving distant parts and indirect trauma to the abdomen. Far too often the vomiting and abdominal pain are presumed to be a result of the primary illness and treatment is delayed until too late by medication and soothing words.

PHYSICAL FINDINGS In general the most important considerations of an initial physical examination are the presence or absence of (1) incisions indicating previous operations and (2) external hernias No examination is adequate without the complete examination of both the femoral and inguinal areas umbilical and incisional hernias are usually obvious Patients with hernias which are not readily reduced should be admitted to the hospital while undergoing more energetic attempts to free the sac contents Evidence of the development of peritoneal irritation is a definite indication for immediate surgery The following case history illustrates this point

CASE C. H No 818109 A sixty year-old man was admitted to the hospital with an immediate history of an irreducible inguinal hernia which had been present about four hours. During this interval, the hernial mass had become progressively more painful and swollen. There were no other pertinent physical findings.

A preliminary flat plate of the abdomen showed the hernial mass with a central gas shadow present in the right groin. Fig. 1

Despite an initial leukocyte count of 1 ,000 cells with ninety per cent neutrophils efforts to reduce the hernia were continued by placing the patient in Trendelenberg position, sedation, and application of cold packs to the inguinal area. Two hours after admission, the hernia reduced itself without manipulation.

However the patient continued to have signs of peritoneal irritation and in a few hours there was a definite increase in tenderness over right lower quadrant. Exploratory laparotomy was scheduled immediately

At operation a gangrenous loop of ileum 35 cm. (14 inches) in length was found lying free in the abdomen a small portion of omentum also showed signs of previous incarceration. The affected bowel was resected and reanastomosed using Wangensteen clamps to effect a closed-type anastomosis.

Four days after operation an increased amount of abdominal distention was noted and a long tube was introduced with the aid of the Smith stylet (Fig 2) Twenty four hours later adequate decompression had been accomplished (Fig. 3) Note the inlying gastric tube to prevent reaccumulation of swallowed air above the long tube.

In thin emaciated patients peristalsis may be visible This is most apt to be seen in the presence of long-standing incomplete obstruction of the small bowel and is generally accompanied by hypertrophy of the intestinal wall The presence or absence of ascites with its frog-like abdominal contours as contrasted to the central protrusion of the abdominal wall attendant with bowel distention should be known to all clinicians As pointed out previously even a severe strangulating obstruction may



Fig. 2. C. H No. 818109 The patient developed ileus postoperatively This roentgenogram was obtained four days postoperatively and shows the extent of the distention at the time a Smith tube was introduced.



Fig. 1 C. H No. 818109 This figure shows an admission flat plate which demonstrates bowel incarcerated in a femoral hernia. Note the mass in the inguinal area with the central gas shadow The distended loops in the upper portion of the abdomen are probably not pertinent except for the slight amount of separation of the loops which may indicate either intraperitoneal fluid or thickening of the intestinal wall itself.



Fig. 3 C. H. No. 818109 This roentgenogram taken thirty hours subsequent to Fig. 2 shows the adequate decompression obtained with a Smith tube in conjunction with an inlying gastric tube.

be present *without* the development of abdominal distention The general appearance of the patient's skin is a good indicator of the state of hydration, but the noticeable loss of turgor and sunken features is a late sign of obstruction and therefore of less diagnostic importance

Careful palpation of the abdomen is extremely important since often in early development of an intestinal obstruction the primary site of the obstruction is indicated by the most tender area and later by accompanying rigidity and muscle spasm Unfortunately the presence of classical signs of peritoneal irritation, muscle tenderness and rebound tenderness usually indicates the presence of a late intestinal obstruction already accompanied by contamination of the peritoneal cavity either chemically or bacteriologically In early intestinal obstruction the signs and symptoms of muscle rigidity and the like may be completely absent, and the absence of such signs must not be taken as indicative of a minor or incomplete obstruction In general the development of tenderness and muscle rigidity is an early sign in cases of strangulated hernia and a late sign in simple obstruction.

AUSCULTATION Auscultation as indicated previously is most important in the diagnosis of mechanical bowel obstruction The characteristic high-pitched tinkle resulting from peristaltic action of a highly stretched gut with a mixture of gas and fluid within its lumen is pathognomonic of bowel obstruction Later with the onset of peritoneal contamination, the abdomen may become more or less quiet. Rectal examination in early bowel obstruction may also be negative however occasionally a large, boggy mass is discovered by manual palpation indicative of a distended, fluid-filled intestinal loop Again, one should be certain to palpate all hernial orifices for the presence of strangulated loops. In elderly patients, the precipitation of urinary retention by the bowel obstruction may necessitate the insertion of an indwelling catheter before an adequate examination can be performed

It should be emphasized that the number and severity of physical signs accompanying bowel obstruction differs markedly with various age groups *In the aged and in infancy the paucity of clinical evidence of obstruction and peritonitis is striking* Not uncommonly an elderly man is seen in the admitting room complaining of a few cramps and perhaps a single emesis. Even though examination reveals only a moderate distention and minimal tenderness, at subsequent operation a strangulating obstruction with widespread peritonitis may be encountered

X RAY FINDINGS Certainly the obtaining of flat and upright films of the abdomen immediately after physical examination is mandatory in every patient in whom an abdominal catastrophe is suspected. Both views are necessary A scout film obtained with the patient supine will reveal the degree of distention the general area of the obstruction and whether the large or small bowel is enlarged (Fig 4) Separation of filled intestinal loops is often indicative of the accumulation of peritoneal fluid and exudate Upright films are of value in demonstrating single loop obstruction which is unable to rise with the change in position. The presence of a single gas filled loop is characteristic of a closed-loop obstruction and the presence of such a loop low in the pelvis may conclusively demonstrate the presence of an obstructed loop of intestine in a hernial ring (Fig 1) At this juncture

the danger of missing significant pelvic findings by taking films primarily of the upper abdomen should be mentioned The clinician must be aware however that x ray examination is only a supplement to a good history and physical examination and the tendency to regard it as being the final method for diagnosis should be avoided If at all possible the x-ray examination should be carried out with a permanent x ray unit in order to take advantage of the Potter Bucky diaphragm higher milliamperage and shorter exposure time rather than attempt the expedient of placing the film cassette under the patient in an emergency room Not only is it difficult for the patient with distention to hold his breath, but the diffuse films may obscure vital detail

Until a definite diagnosis can be made it is undoubtedly unwise, except in rare instances to give the patient barium by mouth in order to determine the level of obstruction. In selected instances barium may be put down a long intestinal tube to outline the nature of the obstruction with subsequent removal of the contrast media through the tube In some instances the presence of a colon obstruction can be quickly demonstrated by the use of a barium enema, but there is danger of forcing barium through a partial obstruction and with the inspissation of the barium, the conversion of an incomplete obstruction into a complete obstruction

In most instances the outline of the colon can be made out on the scout film, even though the bowel may contain little or no gas Its outline is indicated by the presence of fecal matter or fecal matter and small bubbles of gas distributed along its usual anatomical position. The differentiation of mucosal pattern of the small bowel in different regions is not necessarily significant as regards the presence of obstruction but it may add to the general information of the level of obstruction. The essence of distinguishing the jejunum from the ileum depends on the fine mucosal folds and valvulae conniventes of the former which give it a feathery appearance often the valvulae extend across a large part of the diameter In contrast the lower ileum has rather characterless small irregular mucosal folds



FIG. 4 J A. No. 752527 Onset of colicky pains several days previous to admission to the hospital. The patient claimed he had not passed gas or stool for five days. He had not vomited. The patient had a gastric resection two months previously Abdominal films were interpreted as a complete bowel obstruction probably in the ileocecal area.

The figure shows the introduction of a long plastic tube with the aid of the Smith stylet. Intubation of the jejunum was accomplished in five minutes. Previous attempts (fifteen hours) to pass an ordinary long tube had ended in failure.

Ileus Ileus is in effect a *functional* obstruction of the bowel, in contrast to mechanical obstruction largely occupy

TABLE I

DIFFERENTIATION OF STRANGULATED AND SIMPLE BOWEL OBSTRUCTIONS

	Strangulated	*Simple*
(1) Etiology (most frequent)	External hernia (mass)	Adhesive bands (operative scars)
(2) Pain	More severe and tends to be sustained between peristaltic pain	Pain coincident with peristalsis relief between cramps
(3) Vomiting and shock	Appear earlier and are more severe	Occur late
(4) Abdominal spasm, rigidity and tenderness	Present early and more marked	Infrequently present, except later in course of obstruction
(5) Bloody vomitus and/or rectal discharge	Important if present	Rarely present
(6) Response to intravenous fluids and blood and long tube suction	Little immediate response: even progression of abnormal signs, and symptoms	Immediate clinical response
(7) *Roentgen studies*	*Single loop of dilated bowel which often has fixed position*	*Distention is not localized*

ing the attention of this chapter Recognition of the many causes of ileus such as abdominal and thoracic operations peritonitis, acute infectious diseases, trauma either to the abdomen spine or extremities and electrolyte imbalance (particularly hypokalemia) aid in obtaining a pertinent history Distention which may be extreme cannot be differentiated as to etiology by physical examination and similarly only with difficulty by x-ray examination The most important single sign is the lack of peristaltic activity as revealed by auscultation The reservation that a silent abdomen with a history of *previous cramps* may indicate the development of peritonitis subsequent to perforation must be considered.

As pointed out by many authors, the bowel is not "paralyzed" and with decompression by means of long tube intubation and removal of the underlying cause a quick and complete restoration of peristalsis will occur

Differential Diagnosis of Simple and Strangulated Bowel Obstruction The urgent need of operative therapy for strangulating bowel obstructions demands that only if this condition can be completely excluded from the final diagnosis are nonoperative measures to be considered Berry[2] has published an excellent summary of important differential findings a modification of which appears in Table I

The dangers of procrastination in bowel obstruction are of such grave import as to warrant reemphasis It has been the experience of this and other clinics that often the clinician is lulled by improvement in the clinical response of the patient to correction of water and electrolyte deficiencies and particularly to gastrointestinal suction so as to delay definitive operative therapy In such instances the frailties of human nature are best served by setting an arbitrary time limit at which time a definitive course of therapy will be followed If excellent evidence of objective improvement is not present surgical exploration is indicated, since the discussion of the importance of minor changes in the patient's condition becomes a mere intellectual exercise to the detriment of

the patient (See case history O O No 801295)

Mesenteric Embolus and Thrombosis Because mesenteric vascular occlusion is encountered under the impression that the underlying pathology is a bowel obstruction brief mention is made of these occurrences An embolus arising from the left auricle and valves or the wall of the left heart chambers is the most frequent agent resulting in mesenteric emboli Commonly such a catastrophe occurs in a patient with cardiac decompensation in whom prior emboli to the femoral vessels or brain may have taken place

Mesenteric thromboses (venous) are caused by peritoneal and pelvic abscesses with a resulting infected propagating thrombus and operative trauma to the portal system particularly splenectomy with its postoperative hypercoagulability of blood The important clinical signs are a slow progression of symptoms over several days, shock, bloody diarrhea generalized distention of the small and large bowel with little or no peristaltic activity (For additional details see Chapter 24)

Early excision of the involved area followed by primary anastomosis is the operation of choice

Large Bowel Obstruction No section proporting to discuss the diagnosis of small bowel obstruction would be complete without concomitant mention of large bowel obstruction In general mechanical obstruction of the colon is the result of carcinoma of the colon, or more rarely volvulus of the cecum or sigmoid colon, and inflammatory masses associated with diverticulitis In the Scandinavian countries and in Northern Russia, volvulus is much commoner probably as a result of dietary factors In contrast to small bowel obstruction, the clinical signs and symptoms develop much less rapidly and the progression of dehydration and shock may be delayed for many hours. Vomiting is rare except in those patients in whom an incompetent ileocecal valve is present In such a case the signs will closely simulate those of small bowel obstruction. The x-ray appearance of large bowel obstruction is often easier to interpret than that of the small bowel In general, by careful examination of the flat and upright films one can distinguish the point of obstruction A barium enema carefully given so that the medium is not pushed above the point of obstruction will often exactly localize the site of the lesion Extreme distention of the colon results in those patients with a competent ileocecal valve and an obstructing distal malignancy In such instances there is in effect, a closed loop obstruction which unless relieved will perforate at the *cecum* Volvulus of the cecum and sigmoid are comparatively rare in this country X rays will commonly reveal the characteristic large "C" loop of gas with no mucosal pattern. Often a history is obtained of previous episodes of abdominal distention and cramps which were relieved with a forceful expulsion of gas and/or fecal material.

TREATMENT

Intestinal obstruction of mechanical origin is an emergency which demands the cooperation of internist, surgeon, and roentgenologist. The diagnostic procedures and initial treatment of shock, dehydration, and loss of blood cell mass and plasma must be accomplished as soon as possible particularly in elderly individuals in whom obstruction is commoner The persistence of hypotention for any period of time with or without

hypoxia mediates against a successful recovery

Initial procedures to be begun in the emergency room are outlined below

If the patient is in shock and/or dehydrated from repeated emesis, steps are taken immediately to introduce an adequate intravenous infusion. This may be retained while the patient is given the rest of his work up and the necessary x-ray studies If the initial history and examination reveals evidence of the necessity of operative intervention, the operating room should be notified and all subsequent preparations pointed toward improving the patient's condition consistent with accomplishing successful operation In many instances, the patient is too ill to stand for an upright roentgenogram In these instances it is possible to take the flat film on a tiltable x-ray table at an angle of 45 to 60 degrees which is usually not uncomfortable and can be tolerated by even the most severely ill patient.

Formerly upon admission an inlying gastric tube was inserted and attached to Wangensteen's constant suction apparatus More recently however the ease with which a long tube can be placed in the small bowel with the aid of the Smith stylet has made this procedure popular at this clinic. When the patient is taken to the diagnostic unit and preliminary films indicate the necessity of rapid decompression of the small bowel intubation with the Smith tube[9] is initiated immediately In a majority of instances intubation has been accomplished within a few minutes. The necessity of supplementing the long tube with a nasal-gastric suction in order to prevent reaccumulation of swallowed air will be amplified subsequently

As will be reemphasized later the use of long tubes can be maligned, and prolonged attempts to effect their passage or undue reliance placed upon their therapeutic effects may lead to fatal procrastination particularly in the presence of strangulation

Water and Electrolyte Balance. The early recognition by pediatricians of the importance of electrolyte and water balance concurrent with abdominal catastrophes has been adopted and studied intensely by surgeons in the last decade In most instances of high obstruction it is obviously important to replace the immense amount of chloride which has been lost in the vomitus. Even more important is the replacement of water itself As mentioned previously intravenous therapy can and should be started immediately after admission of the patient to the emergency room and continued throughout the interval before a definitive operative procedure may be carried out. This replacement therapy can be started immediately after routine blood and chemical determinations have been begun and subsequently the fluid requirements may be modified as the reports of the blood chemistries are returned.

At this clinic it has been the practice to insert an inlying urinary catheter to insure an accurate check upon the urinary output Both the hematocrit and urine specific gravity are aids in estimating the degree of dehydration but the simplest way of estimating continuing fluid requirements is by recording the urinary output. Intravenous fluid therapy can be adjusted to give an output of at least 40 cc (1 1/3 ounces) per hour A definite loss of skin turgor indicates approximately seven per cent of the body weight has been lost and affords a further estimation of the fluid requirements

Since the extracellular fluids are de

pleted early a basic replacement solution made up of a hypotonic salt solution (4.5 grams per liter) with five per cent glucose is used at this clinic

Subsequent daily fluids can be closely estimated by noting the loss of fluid by suction urine, and the daily insensible loss from skin and lungs which averages 1500 to 2000 cc each twenty four hours. Daily weights are a help in checking the daily fluid balance

Of course, large losses of extracellular fluid and electrolytes are inevitably followed by a disturbance of the intra cellular fluids with loss of fluid and the important intracellular ions of potassium and phosphate This circumstance is not easily nor quickly reversed. Therefore, addition of these ions must be added to the daily fluids from the beginning These deficiencies will manifest them selves in many ways for example a refractive alkalosis has been shown to be correlated with potassion ion de ficiency and only with the correction of this latter deficiency will the patient respond to sodium chloride therapy [7] Ileus and muscular weakness are also common signs of potassium deficiency

The dangers of inducing cardiac ir regularities by administering potassium quickly intravenously and its continued supply in the presence of oliguria must be remembered. (See Chapter 54)

The necessity of administering whole blood to a patient in shock regardless of a high hematocrit is generally recognized. This serves to reverse the existing contracted blood volume and replaces some of the protein loss which accompanies all large losses of body water In addition, more protein is lost in the bowel wall whose capillaries integrity has been disrupted by prolonged anoxia. Similarly large volumes of protein-rich fluid are segregrated in the bowel lumen and must be replaced The protein loss and red cell destruction accompanying peritonitis may necessitate daily transfusions

Other Adjunctive Measures Oxygen has been suggested as a means of reducing intraluminal pressure however it seems obvious that any such effect is minimal in comparison with the efficiency of intestinal suction In the presence of shock there is probably some indication for its use to obviate anoxia.



FIG. 5 J B No 703888 An elderly male was admitted with a history and physical findings suggestive of a peritonitis and pelvic abscess probably from a ruptured appendix eight days previously X rays revealed adequate decompression of the small bowel except for two isolated loops. Operation revealed two loops of small bowel 7.5 cm. (3 inches) in diameter with a measured interval pressure of 10 cm. of water A catheter enterost... was performed, the postoperative cour... was uneventful.

At this clinic the judicious u... of nor-epinephrine added to the ... nous fluids has been employed ... port the vascular tone until it ... The height at which the bloo...

is maintained can easily be controlled by adjusting the intravenous flow. This expedient can be life-saving and is of value in preparing a patient in extreme shock for emergency surgery. Several instances in which a local tissue slough has occurred at the site of injection have prompted the use of an inlying polythene catheter for its administration.

Antibiotics. With the advent of the antibiotics, a powerful therapeutic aid was added to the therapeutic armamentarium of bowel construction. Investigations and clinical experience have conclusively demonstrated their value. Any of the "wide spectrum" drugs can be used effectively. At present, aureomycin is enjoying wide popularity; generally it is added to the intravenous fluids started while the patient is still in the receiving room.

Intestinal Decompression. Prior to the reintroduction and popularization of intestinal decompression by Wangensteen and Paine in 1933[10] the mortality rate for acute intestinal obstruction was from forty to sixty per cent. By 1938 Wangensteen was able to report a mortality rate of eighteen per cent and in 1946 Dennis and Toon[5] noted a mortality rate at this clinic of 10.5 per cent for the period between 1940-46. The use of the antibiotics and an increased knowledge of fluid and electrolyte requirements have, of course, contributed to a lessened mortality rate in recent years.

Nasal Intubation with the Long Tubes. An additional therapeutic agent which has done much to aid in the preoperative preparation of patients with obstruction and as a definitive therapeutic means of treating adynamic ileus is the development of the long intestinal tube (Miller-Abbott, 1938).[1] Many such tubes have been described and their various advantages set forth by their proponents.[4] A summary of the design and use of many of these intestinal tubes was published by Wild.[14]

Briefly, the advantage of these intestinal tubes is the decompression of distal distended loops of small bowel.

Progression of the tube through the intestine depends upon a combination of a distendable balloon to stimulate peristalsis and/or the addition of the small weighted bag to take advantage of gravity. The immediate and serious disadvantage of most long tubes is the circumstance that with increasing amounts of distention, the tubes are progressively more difficult to introduce into the duodenum and jejunum.

Smith[8,9] has reported a technic of intestinal intubation with a long tube by the aid of a flexible stylet with the controllable tip to facilitate introduction of the tube into the duodenum (Fig. 4). This tube is constructed of polyvinyl chloride, is 3 meters (9 feet) long, and has a latex bag at its distal end which can be inflated after intubation by means of a small plastic tubing which is attached loosely to the suction tube. Intubation is accomplished by introduction of the flexible stylet into the plastic tube some 1.2 meters (48 inches) from its distal end. The stylet and tube are introduced into the patient's mouth and down into the stomach; the patient is then positioned on the fluoroscopy table and a short glance of the fluoroscopic screen is used to direct the tube through the pylorus. In one-third of the patients the tube will travel across the greater curvature and through the pylorus without necessitating manipulation of the controllable tip of the stylet. Failure to intube the pylorus in the first attempt can be followed by partial inflation of the stomach with air which facilitates

traversing of the greater curvature The second feature of this stylet which aids in manipulation of the tube in the stomach is a controllable tension mechanism which stiffens the flexibility of the tube so that it can be more easily directed. After the pylorus is intubated the stiffness of the tube can be lessened and the tube introduced past the third portion of the duodenum When this has been accomplished, the stylet is removed and the opening in the tube through which the stylet was introduced is closed with a stainless steel insert. With this technic Smith was able to accomplish intubation of the jejunum in ten minutes or less in seventy per cent of the patients and in thirty minutes or less in ninety per cent of the patients he was unable to intubate successfully eight per cent of the patients Included among the failures of intubation were such pathological conditions as a carcinoma of the duodenum choledochopyloric fistula which resulted in a sharp angulation of the duodenum and several patients in whom intubation could not be accomplished within the time limit set for fluoroscopy At this clinic, the Smith tube and stylet method has been used more or less exclusively in the last few years

Several cautions must be inserted concerning the use of the long tubes lest irreparable harm may result. Firstly long tubes have often been the cause of undue procrastination and thus have resulted in a fatal delay before surgery was undertaken. If definite x-ray evidence of decompression is not obtained within a definite number of hours or if a single loop remains dilated, surgery must be performed (Fig 5) In one clinic, the misuse of long tubes has been demonstrated by the fact that the mortality rate of acute obstruction has been lowered in most cases in which intubation with long tubes has not been attempted or has failed

Secondly the failure to remember that over seventy per cent of gas in the intestinal tract is swallowed air and therefore once the long tube has been placed on suction and has been advanced into the lower jejunum *a gastric tube should also be inserted to obviate reaccumulation of gas above the area decompressed by the long tube* (Figs 6 7) If after forty-eight hours of suction there is a relenting of obstruction, but then a reaccumulation of distention and obstruction when the suction is discontinued, operation should be seriously considered

Operative Decompression The facilitation of resection and subsequent anastomosis of the bowel by decompression at the time of operation should not be overlooked Specifically this can be accomplished in two ways first by insertion of catheter in the small bowel utilizing the aseptic decompression suction method described by Wangensteen,[11] or simple aspiration through a trocar or needle, and secondly decompression at the time of operation by means of a long tube introduced through the mouth The second method can be used in at least eighty per cent of all cases The use of Smith's stylet to stiffen the tube and thus facilitate the manipulation of the tube through the upper reaches of the small bowel by the surgeon has been of great value When the tube has reached the jejunum a small amount of air is placed in the latex bag and the tube can be easily manipulated by the surgeon progressively down the bowel at the same time that continuation suction is applied By careful manipulation a minimum amount of trauma to the bowel wall results. In some cases,



FIG. 6



FIG. 7

FIG. 6. O O No. 801295 This photograph illustrates the accomplishment possible with an insertion of a Smith tube at the time of surgery for decompression of the small bowel. It is noteworthy that an inlying gastric tube is also present.

FIG 7 O O No. 801295 (same case) Seventy-two hours later there is a marked distention of the small bowel distal to the long tube which has occurred as the result of premature removal of the inlying gastric tube. Further decompression with the gastric tube for a period of twenty four hours allowed the bowel to reestablish its peristaltic activity the patient's subsequent course was uneventful.

felt that with adequate preparation, resection adds little risk to an operative procedure, and the indication for accomplishing definitive therapy in one stage are great, particularly in elderly patients Similarly complications such as permanent fistulas and strictures of the bowel which may result from exteriorization make this procedure an unpopular one

Primary Resection The simplest operative therapy for bowel obstruction consists of cutting adhesive bands which in some instances may completely relieve the obstructing mechanism. In such instances the underlying bowel must be scrutinized to be certain that pressure necrosis has not resulted in an area of nonviability If the patient has suffered from repeated attacks of adhesive obstruction, it may be well to employ the method of plicating the small bowel described by Noble If the trauma to the bowel is at all severe or if a short area has suffered multiple injuries from adhesive bands, it is probably justifiable to resect the area and anastomose the bowel. Primary resection and restoration of continuity of the bowel has been the obvious treatment of choice for all instances in which the obstructing mechanism can be removed or in which there are areas of nonviable bowel. In accomplishing resection of a nonviable segment of gut, it is of importance to determine the patency of the vascular supply This is most easily accomplished by visualizing the arterial pulsation of the small terminal vessels along the mesenteric border of the intestine after freeing them from the overlying fat and peritoneum

Several adjunctive tests have been utilized to determine the viability of bowel such as the intravenous injection of fluorescein and observation of the bowel in question under ultraviolet light. However although such measures may be of some value in selective cases it is far better to resect an additional amount of small bowel rather than leave an area of questionable viability In the presence of inflammation, the fluorescein test also seems to be quite unreliable as regards the adequacy of the circulation

In recent years anastomosis of the stomach, small bowel, and colon has been accomplished by the closed technics, utilizing one row of interrupted Lembert sutures With this method the inverted cuff is minimal as confirmed by experimental studies

With large differences in the intestinal lumens to be anastomosed the expedient of placing the clamp on the smaller segment at an acute angle, so as to be able to approximate equal circumferences has been resorted to with good success However the many methods of accomplishing adequate anastomoses testify to the adequacy of the several technics One can only recommend a method which the individual surgeon feels most competent to perform.

Dennis and Varco[8] have suggested an additional method of removing bowel incarcerated in an external hernia In those cases of longer duration where necrosis of the bowel may have occurred already they resect *en masse* the entire sac and its contents The bowel is amputated outside of the sac and anastomosed. The danger of spreading the contaminated fluid contained in the sac is thus minimized

Therapy of Large Bowel Obstruction The role played by the ileocecal valve in converting a simple occlusion of the colon into a closed-loop obstruction has already been alluded to. In such instances distention may increase rapidly perforation usually occurs in the cecum Roentgen examination will generally reveal the site of obstruction but if some doubt remains, a barium enema can be done *cautiously* Since a majority of colon obstructions result from primary carcinoma or diverticulitis of the left colon and sigmoid, the simplest effective therapy is a transverse colostomy If one encounters an enormously dilated colon a large needle attached to a suction system can be introduced into the colon at the site of exteriorization in order to obviate immediate rupture and to facilitate performance of the colostomy

Caution must be exercised when placing stitches in the thin bowel wall In most instances one can use the appendices epiploicae and the taenia in suturing the colon to the peritoneum The exteriorized loop can be aspirated postoperatively later a catheter inserted and finally be unroofed on the third day Wangensteen[13] has detailed the technic employed at this clinic

A second expedient is performance of a cecostomy particularly for obstruction of the right colon The disadvantages of this procedure are a less adequate deviation of the fecal stream and a more direct complication of its performance such as contamination of the peritoneum and fistula formation

A catheter enterostomy may be resorted to for decompression of the right colon by inserting a tube in the distal ileum (Witzel technic) and directing the tip through the ileocecal valve

Volvulus of the Colon: Volvulus of the sigmoid colon can be treated by nonoperative means as suggested by Bruusgaard[2] With the aid of proctos

copy a soft catheter is inserted past the site of obstruction and the twisted loop decompressed This usually allows spontaneous detorsion but unfortunately volvulus recurs in thirty per cent of the cases and therefore an interval resection and anastomosis of the affected loop is indicated The danger of the non operative method is the reduction of the gangrenous sigmoid without recognition of its condition

Obstructive resection (Rankin or Mikulicz technic) has had its advocates particularly if gangrene of the sigmoid has ensued however these methods are less acceptable because of the prolonged hospital stay and necessary secondary procedures.

Immediate primary resection of the twisted loop has found favor recently and with the aid of the antibiotics can be performed with a reasonably low mortality Its advantages are direct observation of questionably viable bowel and completion of the necessary therapy in one stage

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The Bleeding Colostomy

BLEEDING from any site is always alarming to the patient, and is an emergency from his viewpoint. Perhaps this may be due to the fact that a little blood makes a large stain In reference to a colostomy the presence of blood at the stomal site may or may not be an emergency However it is always a situation which brings to the patient mental unrest and often fear For this reason a discussion on the bleeding colostomy is included among the subjects presented in this volume on emergency surgery

Colostomy bleeding is usually bright red when the source of hemorrhage is in the colon or terminal ileum On rare occasions the passage of "coffee ground" blood may be noted. This was seen in one of our patients who developed a bleeding peptic ulcer A situation of this type is a rarity When blood is passed through a colostomy it is usually red in color The same is true of bleeding about a colostomy or bleeding due to the disease process for which the colostomy was performed.

Etiology· The causes fall into one of two categories physiologic or pathologic

The physiologic causes

1 Dietary indiscretion.
2 Excessive cleanliness.
3 Normal reaction to irritation.

The pathologic causes

1 Stricture at the fascial or skin level
2 The presence of benign or malignant polyps
3 The recurrence of carcinoma.
4 Colitis.
5 Arteriosclerosis

In an effort to determine the causes for colostomy bleeding an adequate history is quite essential. The patient should be interrogated as to the care of the colostomy Further questioning concerning the usual diet and any recent deviation therefrom is often revealing One of these methods of questioning may reveal a physiologic factor precipitating the passage of blood through the colostomy

THE LESS SERIOUS OR PHYSIOLOGIC CAUSES Sudden changes in diet or dietary indiscretion may stimulate an irritation of the colostomy mucosa which may result in the bleeding This is especially true in colostomies formed from the ascending colon Certain foods are notorious for irritating the mucosa These foods are "poorly" cooked peas, beans, corn and sausage frankfurters, and similar meat products

Physiologically the colostomy site is analogous to the anorectal area As such it is unclean to the same degree as the anal orifice Many patients with

colostomies fail to realize this similarity and they become excessively clean Specifically they cleanse themselves too often They scrub the colostomy and apply ointments and sweet smelling liquids to eradicate the colostomy odor Many of these procedures irritate the stoma, producing a "raw" surface which bleeds easily The presence of bright red blood alarms the patient and medical care is sought quickly Excessive cleanliness is also manifested by the overindulgence in colostomy enemata. Some colostomy patients employ the enema routine several times daily This is excessive Patients must be taught that colostomy function can be regulated and controlled with a proper dietary regimen They should be instructed in the use of the enema The enema nozzle is a potent factor in the production of mucosal irritation which will stimulate bleeding. A warning should be given against the use of caustic soaps employed in enema solutions The best solution is a mixture of salt and water

Another source of irritation and bleeding at the colostomy stoma is rough gauze placed over the colostomy This frequently produces a raw stoma which will bleed freely For cleansing purposes the ordinary disposable paper tissues are preferable to gauze

THE MORE SERIOUS OR PATHOLOGICAL CAUSES The more serious causes for colostomy bleeding are found in the pathologic group Bleeding which occurs several months following operation may result from the formation of a stricture at the stomal site. This usually is found at the skin or fascial plane layer During the process of healing a stenosis at the colostomy exit may result. When *excreta* attempt to pass this area, force is necessary Over a prolonged period of time this force may be sufficient to stimulate mucosal irritation Constant irritation of this type is sufficient to produce bleeding. Stricture is a frequent cause for obstructive constipation The presence of constipation further aggravates the irritation and thus a vicious cycle is established. Severe stricture may result in a pencil-like stool The diagnosis of this condition is readily made when the examiner attempts to insert his finger into the colostomy orifice

It is not infrequent that blood from a colostomy is secondary to a benign or malignant polyp located proximal to the colostomy opening. Rarely do polyps grow rapidly shortly after operation Usually the lesion existed at the time of operation and was overlooked. An aid in the diagnosis of bleeding secondary to polyps is the proctosigmoidoscope When this procedure cannot be performed satisfactorily a barium enema (through the colostomy stoma) may reveal the presence of a polyp

When a colostomy has been formed for carcinoma, bleeding may be a sign of recurrence or extension of the disease process If a palliative loop colostomy has been performed, bleeding may originate from the primary lesion This is not a surprising phenomenon. In those instances where the entire lesion is believed to have been removed, and the previously discussed etiological factors have been eliminated, the recurrence or extension of the neoplasm must be considered. Adequate study of the colostomy will usually demonstrate a recurrence of the disease.

Bleeding from a colostomy in a patient with colitis is a different situation again. If the patient has a functioning ileostomy plus a temporary *nonfunctioning* colostomy opening bleeding from the colostomy stoma is a natural ex

pression of the disease process If a colostomy has been performed for ulcerative colitis in an effort to preserve a portion of the colon, then colostomy bleeding argues for the fallacy of colostomy for colitis patients Experience has taught that ileostomy is the procedure of choice in the management of ulcerative colitis The performance of a transverse colostomy in an effort to prevent the spread of ulcerative colitis from the distal to the proximal colon is also fallacious Although it is believed that the majority of colitis cases commence in the vicinity of the rectum nevertheless colitis may assume a segmental appearance quite similar to segmental ileitis hence again the error of performing a colostomy in these patients This fact further negates the belief that colitis will not "jump" a colostomy It is not a question of passing from one colonic limb to another but rather it is a question of the nature of the disease process itself The pathology may be dormant in one area only to reveal itself after the appearance of the lesion in a different segment.

Many patients subjected to a colostomy for carcinoma fall into the older age group In this class of patients varying degrees of arteriosclerosis may be present. It is possible for an arteriosclerotic vessel to degenerate to perforation with a resultant hemorrhage into the lumen of the colon This situation was seen on one occasion with the rapid onset of death before any decisive remedial procedure could be instituted. Under certain circumstances bleeding if visualized may be controlled with the electric cautery

In conclusion, it may be said that the passage of blood in a colostomy area demands certain investigations These are

1 Adequate history to eliminate the possibility of irritation dietary indiscretion and excessive use of the enema

2. A thorough examination of the colostomy is imperative This examination should include digital examination of the colostomy opening, proctosigmoidoscopy and a barium enema when necessary

Treatment Bleeding may be controlled by correcting the etiologic agent. Surgery may be necessary to correct a stricture or to remove a polyp Recurrence of carcinoma may or may not be amenable to surgery depending upon the extent of the recurrence Radiation therapy usually is ineffectual The electric cautery is a valuable asset in the control of bleeding from an arteriosclerotic vessel. Hemostatic agents such as thrombin oxycel etc are usually not effective because of the nature of the bleeding Since these agents cannot cure the underlying pathology or physiologic dysfunction they find little utility in the management of colostomy hemorrhage

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Acute Emergencies Arising in the Colon, Rectum, and Anus

In a proctological practice acute emergencies are not as common as in a general surgical practice When they occur these cases present one or both of the two commonest symptoms of any emergency bleeding and pain. To these may be added two others giving rise to emergencies of a lesser catastrophic character but nonetheless, of possible serious consequences prolapse and the presence of a foreign body

It seemed to us of a more practical value to discuss the problems that may arise according to the major presenting symptoms rather than the usual text book descriptions of separate entities The presenting complaint may be directed to the anorectal region, or to the abdomen.

ANORECTAL GROUP

Pain Anal pain is one of the most excruciating sensations that can be experienced. This is well known to the surgeon when comparing the pain caused by different types of surgery with the postoperative pain of a hemorrhoidectomy These patients seek prompt relief soon after symptoms begin, for they know that physiological functions must continue and the consequences of these normal actions are painful if they fail to seek relief

In order of frequency the commonest causes of anorectal pain requiring emergency care are Fissure with sphincter muscle spasm, thrombotic hemorrhoids, abscesses and foreign bodies

Fissure with Anal Spasm The addition of anal spasm to a fissure is necessary in order to include this entity as one of emergency nature Fissures are sometimes seen that do not give rise to acute pain these are usually coincidental findings during anoscopy but when a fissure is associated with anal spasm it gives rise to pain so severe that the patient must seek prompt relief A fissure may vary from a simple tear in the modified anal skin, to a deep burrowing ulcer with the typical sentinel tag It is usually a disease of adults, and has a direct relationship to the fast pace of living of our civilization

The predisposing factors to the development of a fissure are both anatomical and physiological During defecation the only fibers of the external sphincter that are not dilated in conjunction with the internal sphincter are those fibers comprising its most external subdivision, the subcutaneous portion These fibers form

a complete circle around the anus while the adjacent deeper fibers of the superficial portion of the sphincter decussate both at the anterior and posterior median lines This leaves the tissues covering the anterior and posterior segments of the subcutaneous sphincter without much support, and therefore subject to trauma during bowel movement that is why fissures are usually found in the midline The posterior midline must suffer the brunt of the action and be more susceptible to injury as fissures are most commonly found in this area. Aggravation of the above-existing conditions comes from the irritation of the anal wound during subsequent bowel actions in turn causing a "protective" sphincter spasm which is responsible for the presenting symptom of acute pain The diagnosis of a fissure is obvious enough if the patient can be examined. Usually though, in an emergency case it will be impossible to approach a patient without him or her feeling an extreme degree of apprehension towards any type of examination. If sufficient cooperation can be elicited from the patient, a perianal injection of an anesthetic (aqueous or in oil) may be given it is important to wait until the anesthetic agent has taken effect in order to do an adequate examination of the anus and lower rectum In some cases it will be impossible to come any closer to the patient than the door of the examining room In such cases the surgeon is justified in hospitalizing the patient and going ahead with examination under anesthesia (intravenous) or a regional anesthetic (transsacral caudal or a low spinal) We will emphasize here that definitive treatment for any anorectal condition should be done if and at the time an anesthetic of this type is necessary for examination. The treatment of anal fissures goes along the same anatomico-physiological points brought out in the etiology of this condition, together with the principal axiom of anorectal surgery that of establishing sufficient and uninterrupted drainage to the exterior for any anorectal wound. An elliptical removal of tissue should be done The proximal papilla and crypt (which are often involved in the pathological process) the edges and base of the fissure and the sentinel tag, if present, are excised. The fibers of the subcutaneous portion of the external sphincter must be divided in their entirety When this is done the severed edges of this part of the muscle will be seen to retract away from the median line leaving a smooth, shallow groove from one end of the surgical wound to the other

THROMBOSED HEMORRHOIDS This is the second commonest cause for which a patient with anorectal pain will place an emergency call to a physician. There may be no history of trouble with hemorrhoids in the past, or there may be a long-standing association of the patient with anal protrusion bleeding, and pain In any event the patient will usually diagnose his case for the examining physician If the condition is of an emergency nature the findings will be those of one or several large bluish hard, and tender masses either covered by skin or prolapsed through the anus and covered with mucous membrane The thrombosis may involve the veins of one anorectal quadrant, or the entire ring of external and internal hemorrhoidal veins The etiology of hemorrhids is subject to much discussion but it has to do with a weakened vein wall and an increase in the intraluminal pressure (constipation pregnancy intra abdominal tumors etc) Thromb-

is brought about by laking or stagnation of blood in the dilated veins (sphincter spasm) or because of injury to the vein wall In the latter case injury may be so great as to rupture the vein and a hematoma form rather than a "thrombosed hemorrhoid"

Hemorrhoids are a disease of adult life though uncommonly as in the case of anal fissure or any of the anorectal conditions under discussion they may be found in children

The treatment of these cases may be carried out in the office The principle of treatment is the evacuation of the thrombus from the vein or tissues involved In some cases it will be just as easy to remove the entire vein or group of veins involved by thrombosis, in which case the treatment is more definitive An anesthetic is injected in the perianal tissues (subcutaneous and muscular) under guidance of a finger placed in the anorectal canal (this is possible in practically every case of thrombosed hemorrhoids, but not in cases with painful fissures) Because of its more lasting effects, our choice is an anesthetic agent dissolved in oil. Additional support may be obtained from the quicker-acting aqueous anesthetic solutions The injection usually consists of 5 cc. of material for each side of the anus to be anesthetized. One needle puncture is all that is usually necessary This is made in the posterior midline about 3 cm ($1\frac{1}{4}$ *inches*) away from the anal orifice Injection is then carried out in three planes being careful not to "pool" the oil in any one spot. It is best to inject as the needle is introduced or withdrawn from the tissues to be anesthetized. The three planes to be injected are the subcutaneous area under the thrombotic veins (external pudendal nerve branches) the external superficial sphincter area, and the deeper ischiorectal area about Alcock's canal (internal pudendal nerve) In some cases particularly if the aqueous solutions are used it will be necessary to inject only the subcutaneous plane this is particularly true in cases of small thrombotic hemorrhoids In the more severe case, hospitalization and an emergency hemorrhoidectomy must be done It is true that there is no great emergency in these cases as far as life preservation is concerned, but because of the severe agony the patient is in it is only right to treat these cases as emergencies

Abscess in and About the Anorectal Areas A patient with an abscess in this location presenting an emergency problem will do so either because of excruciating pain or the presence of a high fever or because of spontaneous rupture of the abscess As in cases of abscess in any other part of the body symptoms have usually been present for several days and by the time the patient is seen by the physician, fluctuation will be present and the abscess will be "ripe" for incision and drainage An anorectal abscess may be superficial or deep The superficial group includes those originating as infections of skin structures (hair follicles, sebaceous glands, apocrine glands) and those affecting the deeper structures but external to the levator ani muscles (subcutaneous and ischiorectal abscesses) Almost invariably the latter group originates in infected sinuses from the anorectal canal, and will, upon surgical drainage or spontaneous *rupture*, be converted into anorectal fistulae The magnitude of the signs and symptoms of this superficial group of abscesses will increase in direct proportion to the depth of the abscess The deeper the abscess the greater the ease and possi

bility of spread with involvement of large areas This is well demonstrated by the "horseshoe" abscess which will surround, more or less completely both sides of the anorectal canal

The superficial group of acute abscesses are self-evident to examination tenderness swelling heat, and fluctuation are characteristic An internal opening will probably be found in the posterior *midline* on anoscopic study if the abscess is of the subcutaneous or ischiorectal type Thorough anoscopy *is not usually possible because of serious* discomfort to the patient.

The deep rectal abscesses may be divided into two groups one involving the rectal wall alone (submucosal abscess) and another group found localized in the perirectal tissues above the levator ani which are therefore in the true pelvis (pelvirectal and retrorectal abscesses) The patients with these deep abscesses are not greatly distressed by pain unless spread of the abscess occurs into the ischiorectal fossa (through the levator ani) or into the lesser pelvis (pelvic cellulitis) In the former case, the signs and symptoms of the commoner ischiorectal abscess will occur and the communication of the abscess cavity with a supralevator pocket may be discovered only at the time of surgery *In the latter case the pelvis* being involved the signs and symptoms of pelvic peritonitis will be found The usual presenting complaints of these abscesses are fever a sensation of something in the rectum that cannot be expelled, and frequently difficulty in urination Diagnosis in these cases is based on the digital-rectal examination Proctoscopy will, of course be of great *help in the submucosal type* since a point of rupture may occasionally be seen.

The emergency treatment of abscesses in the anorectal area is *generally* the same as that for any abscess in any location *The pus must be evacuated*, and sufficient unroofing of the cavity must be done to preclude closure of the wound and recurrence of the abscess In the case of the superficial abscess this can be accomplished as a rule as an office procedure Ethyl chloride anesthesia is sufficient for the cutaneous abscess, and *sometimes* for the deeper ones In treating subcutaneous or ischiorectal abscesses, *it is usually best* to inject just enough of an aqueous anesthetic solution intracutaneously to allow for incision and resection of part of the roof of the abscess cavity The incision should be made parallel to the external sphincter muscle in order to avoid injury to this structure It should also be made over the most fluctuant and swollen area.

Sometimes it will be necessary to hospitalize a patient, particularly if the abscess is very large the temperature very high or pain too severe to let the patient return home Intravenous anesthesia has been found to be excellent for incision and drainage of these abscesses in a hospital Under such circumstances, and if an internal opening is found communicating with the main abscess cavity it may be possible to do a fistulotomy at the same time This may assure the patient a greater chance for more complete cure If this is not done a fistulectomy or fistulotomy will most likely be necessary at a later date The insertion of a soft rubber tissue or iodoform gauze drain will help to keep the cavity open although an adequate unroofing is sufficient Tight packing of the cavity should always be avoided A seton may be used if several openings are necessary to drain adequately a

large branching cavity Careful digital exploration of the abscess is justifiable and sometimes necessary in order to break up any loculations of the abscess cavity

The treatment of submucosal abscesses is simple incision of the mucosa over the abscess along the entire fluctuant area, but particularly along the distal most dependent part of the abscess As in the case of the superficial external abscesses unroofing should be practiced if possible but to a much lesser degree This procedure can usually be done without anesthesia and through a proctoscope but sometimes because of anal spasm, it will be necessary to give a general (intravenous anesthetic The sphincter should be dilated following this procedure to prevent any undue increase of the intraluminal rectal pressure

The retrorectal and pelvirectal abscesses are not treated by a transrectal route but by incisions dissecting along the perianal and perirectal tissues until the abscess cavity is entered. In the case of the retrorectal abscess the incision is made posterior to the anus and along one of the coccygeal lateral borders The incisions used for the pelvirectal abscesses are lateral to the anus, into the ischiorectal space and then up through the levator ani muscles The insertion of rubber tube type drains is essential to prevent closure of the cavity at the level of the levator ani leaving, if such is the case an hourglass-shaped abscess cavity difficult or impossible to heal unless reoperated upon.

Adjunct methods of treatment, in the case of painful ailments of the anorectal canal are the use of hot sitz baths suppositories or ointments and hot compresses of witch hazel or boric acid solutions

Foreign Bodies There are two types of emergency cases that may be discussed under this heading. The first one is the case where pain is experienced by a patient because of injury to the anorectal area from an ingested foreign body such as a bone (chicken, fish pork) needle pin, etc., or from a foreign body of an external source such as a piece of glass nail bayonet, enema tip bullet, etc. In the second case pain has little if anything, to do with the emergency the patient is, under these circumstances extremely over-anxious and apprehensive because of the loss of an object into the rectum (enema tip etc.)

The treatment of the first group those with pain, consists of the removal of the ingested foreign body if still present (usually found in the area of the crypts) or of the piece of glass, nail, etc. found protruding from the exterior In some cases (bayonet, knife, bullet) the history of a wound by the injurious body is all that will remain of its presence. Bleeding must be controlled and necrotic tissue, if present, should be removed Once this is done the best type of treatment for any of these cases is palliation. One can do more harm by trying to repair the damaged tissues shortly after injury than by waiting two or three weeks and studying the real extent of the damage done In case of severe lacerations or destruction of the rectum, anus, peri rectal tissues a colostomy will often be necessary

The treatment of the second group of patients (those who lost an object by inserting it into the rectum) revolves around the finding and removal of the foreign body This may be extremely easy or it may tax the ingenuity of the most astute proctologist.

BLEEDING EMERGENCIES OF THE ANORECTAL AREA

In a proctological practice there are few conditions giving rise to bleeding sufficient to be classified as emergency cases As a rule bleeding cases seen as emergencies have been bleeding for several days prior to consultation The commonest real emergency is the case of postoperative hemorrhoidal bleeding Other causes of bleeding are internal hemorrhoids chronic ulcerative colitis carcinoma adenomatous polyps of the rectum and cases of external injury to the anus or rectum. The latter have already been mentioned and will not be discussed again under this heading

Bleeding from the anorectal area is usually of a bright red color but clotting and time will deepen the color The diagnosis of the source of the blood is not too difficult the history of a previous anorectal operation of protruding hemorrhoids of bloody diarrhea, or of external injury are extremely helpful A proctoscopic examination will invariably expose the source of trouble. As in the case of severe blood loss from anywhere a patient with severe anorectal bleeding should be hospitalized. Bed rest, soft diet, and sedation are essential sometimes precluding the necessity for any other form of treatment. Blood studies for the determination of the platelet count, as well as bleeding and clotting time will be helpful in some instances in guiding proper treatment If the bleeding is severe enough blood pressure and blood counts should be obtained at required intervals Blood transfusions should be given as often as necessary after proper blood studies

In particular cases of postoperative hemorrhoidal bleeding are usually amenable to packing of the lower rectum and anus The bleeding in these cases originates from the submucosal artery of one of the quadrants resected at surgery Rather than exploration of the surgical area and ligation of the artery amidst very friable, edematous tissue we have found it best to pack the lower rectum with a material such as oxycel or gelfoam or if necessary an hourglass-shaped gauze pack that can be applied and pulled tightly against the lower rectum Packing of the lower rectum is best achieved under anesthesia preferably intravenous The same treatment applies for bleeding internal hemorrhoids though it is sometimes possible to give the patient an injection of quinine and urea to stop the bleeding a hemorrhoidectomy may be recommended as a matter of choice

In cases of carcinoma of the rectum or bleeding adenomatous polyps the electrocoagulating, or the electrodesiccating machines can be used to great advantage The polyps may be snared and their bases coagulated and the carcinoma may be coagulated enough to stop bleeding until proctectomy can be carried out after due preparation of the patient

A more difficult problem is offered by cases of chronic ulcerative colitis involving the rectum We believe it best to discuss severe bleeding from chronic ulcerative colitis as a whole rather than separating these cases into those bleeding from the anorectal area and those bleeding from the colon. The reason for this is based on the fact that if blood loss is great enough to make emergencies out of these cases the colitis also involves most of the large bowel In the majority of these cases *Massive gastrointestinal bleeding is a serious problem regardless of the etiology* In cases of chronic ulcerative colitis the diagnosis is usually known to the patient

before any serious complication occurs therefore the cause of bleeding will be obvious In a matter of hours these patients may exsanguinate themselves severely Treatment in these cases follows the usual lines of hospitalization with absolute bed rest, sedation a non residue high protein and vitamin diet, sufficient laboratory work to keep track of the degree of blood loss, transfusions, and very close observation Laxatives or enemas are to be completely avoided. If bleeding is uncontrollable by these usual means it may be found necessary to establish an ileostomy and even do a concomitant total colectomy

Due to the great advances in the fields of transfusions (either intravenous or intra-arterial) and anesthesia these procedures may be carried out with a fair amount of safety Fortunately those cases requiring emergency surgery because of bleeding from chronic ulcerative colitis are not so common Bleeding usually stops and ileostomy and colectomy may then be carried out under less hurried conditions A word of warning If bleeding occurs which is severe enough to warrant thoughts of emergency surgery for ileostomy and colectomy and this subsequently subsides without the necessity for immediate operation, these cases should be prepared for surgery in the not too distant future and under less adverse circumstances instead of continuing with medical management of the case

Massive hemorrhage from the lower gastrointestinal tract seen in proctological practice, may also arise from a Meckel's diverticulum, regional enteritis or enterocolitis diverticulitis, neoplasms of the colon and rectum, and lymphogranuloma Ulcerative colitis of amebic origin may also be the cause of severe bleeding

Individual problems arise in every one of these disease entities and they must be coped with as they arise The bleeding observed from diseases involving the lower part of the small bowel and colon is usually of a dark red or bright red color though black tarry material is not rare particularly in the case of the higher lesions Therefore it is sometimes impossible to distinguish the bleeding from the upper gastrointestinal tract from that of the lower part this can be further complicated by the fact that when bleeding is severe enough it may be seen to be almost bright red in color at bowel movement, even though arising from a duodenal ulcer Proctosigmoidoscopic and barium enema examinations done as emergency measures, will often disclose the cause of lower gastrointestinal bleeding. Once the etiology is known, treatment should be established along the usual channels for that particular disease Exploratory laparotomy may have to be resorted to in cases where bleeding will not respond to the conservative measures previously outlined in this chapter Several instances have been reported in the literature where exploratory laparotomy failed to reveal the cause of bleeding· these cases are usually in older individuals where the rupture of an arteriosclerotic vessel may possibly account for the trouble Exploratory laparotomy should be performed only after the diagnostic facilities at hand are exhausted and the patient will not stop hemorrhaging At the time of intervention, a Meckel's diverticulum, or polyp may be removed, or if necessary a segmental resection performed. Because we are operating to save the patient from bleeding to death, the bowel will not have been prepared adequately for surgery so greater care than usual should

be exercised to prevent contamination of the abdominal contents Recently *very promising drugs are under investigation* throughout this country which are capable of greatly decreasing the bacterial count even when used at the time of operation thereby decreasing sepsis to a remarkable extent In any case the preoperative and postoperative use of penicillin and streptomycin combinations, or aureomycin terramycin and neomycin will sufficiently guard against the development of peritonitis in most of these cases

ACUTE, PAINFUL EMERGENCIES ARISING IN THE COLON

This group of patients may be classified into three classes depending on the etiology of the pain (1) Obstructions (2) cases of perforation, and (3) abscess formation.

Obstruction Cases of colonic obstruction vary to a certain extent, from those of small bowel obstruction, but the signs and symptoms are more or less similar The former cases are usually in the older age group since carcinoma of the colon is responsible for most of them Other causes are diverticulitis intussusception volvulus, hernia chronic ulcerative colitis adhesions congenital atresia of the colon, imperforate anus gallstones worms, mesenteric thrombosis, and others less frequently seen

The diagnosis of these cases will depend a great deal on the history obtained from the patient. As a rule symptoms have been present for some time prior to the consultation Generalized abdominal distention, intermittent crampy pain, nausea vomiting, dehydration and hemoconcentration are all present In cases where the blood supply of the bowel is interrupted or strangulation has occurred, tenderness both superficial and deep will be present. *Digital-rectal examination*, proctosigmoidoscopy a flat plate of the abdomen and the judicious use of a barium enema will all help in making the diagnosis The treatment of the conditions causing obstruction of the colon is discussed elsewhere in this text. We prefer therefore to limit our brief discussion to the commonest emergencies of this type obstruction in cases of carcinoma of the colon or diverticulitis Both of these conditions present more or less the same picture narrowing and stricture of the bowel has developed slowly previous signs and symptoms of partial obstruction are easily obtained from the patient progressive constipation and rectal bleeding are present. A flat plate of the abdomen will usually show distention of the proximal colon and small bowel, sometimes fluid levels are present In the majority of these cases a sigmoidoscopic examination will disclose some evidence of trouble in the sigmoid as this is the area most commonly involved by obstructions of this type Careful insertion of barium will reveal the definite level of obstruction if this is not evident on the flat plate or by sigmoidoscopy Our treatment of choice in these cases has been the establishment of a colostomy of the loop or *double-barrel type* in the area of the right half of the transverse colon We prefer colostomy over cecostomy in this type of case because with colostomy we can deviate the entire fecal stream Prior to, during and after establishing the colostomy careful study and correction of fluid and electrolyte imbalance are carried out The use of Levine or intestinal tubes will aid in rapid decompression of the distended small bowel

In cases of lesions located in the transverse colon exteriorization of the lesion still finds an occasional place. Obstruction of the right colon is usually not complete because of the liquid consistency of the fecal stream; when it occurs, cecostomy or preferably appendicostomy may be used to advantage. Definitive treatment to be carried out later will be resection of the area involved, whether it be carcinoma or diverticulitis.

The causes of obstruction of the colon in children are discussed in another chapter.

Perforation. Perforation of the colon may be secondary to an underlying disease (chronic ulcerative colitis, diverticulitis, benign or malignant ulcer), caused by injury (stab wound, bullet wound, compression injuries, air jet injuries), or it may follow abdominal surgery (postoperative leak at the site of anastomosis). Each one of these groups of patients gives a different history but the physical findings are similar. In the first case the patient will give the characteristic history of the underlying disease. The patient almost always knows of the presence of chronic ulcerative colitis or diverticulitis in the colon, because perforations come late in the course of these diseases and diagnosis usually has already been made. Frequently a history of partial or complete obstruction of the colon will be obtained prior to sign and symptoms of perforation. When the latter occurs, walling off of the fecal contaminants may be successfully accomplished by omentum and intestines, in which case an inflammatory mass, with signs and symptoms of localized peritonitis, and/or intra-abdominal abscess are found; therefore, emergency surgical procedures are not necessary. If walling off of the material coming from the perforation is not successful, the signs and symptoms of acute spreading peritonitis will be elicited by the surgeon. Occasionally rupture may occur in the parts of the colon void of any peritoneum, in which case symptoms and signs are milder but steadily increase to a point where in a matter of hours the only justifiable procedure seems to be abdominal exploration. Sudden pain may be experienced by the patient, but more commonly pain is gradual in onset. The only difference from a ruptured appendix may be the extent or location of the patient's findings. At first, anorexia, pain, anxiety, tenderness, and muscle rigidity over the perforated area occur; then nausea, vomiting, a nonfunctioning colon, and increased pulse, respirations, temperature, and white blood count. Still later signs of spreading peritonitis are evident, such as diaphragmatic irritation (shoulder pain, limited inspiration), signs of pneumoperitoneum (distention, tympany over liver area, evidence of air in an upright abdominal x-ray film), and those accompanying a severe toxic state (dehydration, hemoconcentration, apathy, hippocratic fascies, etc.). Treatment in these cases is carried out as soon as the diagnosis is made. The principles to follow are: The placing of the involved colon at rest, the exteriorization of the perforated area. Closure of the perforation is not feasible in these cases because the bowel is severely inflamed and friable. In case of diverticulitis, a colostomy (usually right transverse) is made; the area where the perforation occurred is usually bound down to the parietal wall by the surrounding structures, and liberation of the involved segment may cause more damage to the patient; the local treatment consists of draining this area with the probability

of establishing a fecal fistula The latter will be resected at a later date, together with the involved segment. Sometimes the fecal fistulas established in this manner will heal spontaneously

Perforations of the colon in patients with chronic ulcerative colitis do not seem to be accompanied by the local, defensive walls established by other inflamatory perforating diseases These patients either do not have an adequate reparative power by the time perforation occurs or the degree of perforation and amount of contents spilled into the abdomen are much greater than in cases of diverticulitis Whatever the case may be peritonitis is usually widespread, and recovery of these cases was zero before the discovery of the modern antibiotics Since the new era recovery is still uncertain The entire colon was involved by the colitis in all the cases we have seen and establishment of an ileostomy was imperative As stated previously the colon is not attached or bound down to a great degree so that either exteriorization of the involved segment or partial or total colectomy can be carried out. The magnitude of surgery to be done will vary with each individual case. If the patient is still in fair condition, there is no reason why resection cannot be carried out as an emergency procedure

Patients with traumatic perforations give a typical story and there is no problem in establishing a diagnosis In cases of perforation of the colon due to contusion or compression of a segment of bowel diagnosis may be retarded and more difficult to make In the latter case close observation of the patient is extremely important. Contusion or compression injuries to the abdomen are treacherous and the patient may give no serious or worrisome symptoms for several hours after injury If abdominal pain persists for several hours if signs of abdominal wall irritation occur or if nausea and vomiting persist it is perhaps safer to explore these cases rather than to treat them conservatively A surgeon finds few problems more trying to his diagnostic acumen than a practically asymptomatic bowel rupture following an automobile accident. Knife and bullet wounds penetrating the abdominal cavity are, of course, explored as a routine procedure

Perforations, or separations at the site of anastomosis following resections are less frequently seen today because of better suture materials and a more general understanding of surgical principles but unfortunately they still occur Due to the previous recent surgery walling off of the perforated site has usually been accomplished. A localized abscess occurs with the typical signs and symptoms of tenderness, fluctuating mass elevation of temperature and pulse, abdominal distention (partial or complete obstruction) and toxemia. Treatment will follow along the same line as perforations having any other etiology Adequate drainage of the perforated site is imperative, and can usually be done through the primary operative wound Proximal colostomy if not previously established is necessary in many of these patients to avoid further spilling of feces into the abdominal cavity

Abscess The emergency treatment of intra-abdominal abscesses once diagnosis is certain can be constructed from what has been stated in previous paragraphs Abscesses usually follow perforations in areas of diverticulitis or acute appendicitis They form masses of great proportion and are not difficult to diagnose Incision and drainage of

the abscess is imperative and urgent The establishment of a proximal colostomy will depend on the amount of stenosis and obstruction to the colon present in each individual case As a rule colostomy will not be necessary as an emergency procedure Antibiotic drugs hot, wet dressings and intravenous feedings are all necessary adjuncts in the treatment of these patients We have not yet reached the point of universal agreement as to the proper dosage of the antibiotics used We are inclined to use larger doses than necessary but there appears to be little, if any harm in this practice

RECTAL PROLAPSE

Emergencies occur in patients with rectal or rectosigmoidal prolapse only rarely Usually this is a rather benign condition with a long history of its presence Emergency care is necessary only in those cases of prolapse of the rectum through the anal sphincter when the small bowel is carried down into the protruded peritoneal sac Acute obstruction, or even strangulation of the small bowel may occur The signs and symptoms of obstruction, coupled with the physical findings of prolapse and an unusually large, tender prolapsing mass should make the surgeon aware of the condition to be dealt with Nonsurgical reduction of the prolapse and small bowel is possible in most instances but occasionally abdominal exploration and investigation of the status of the involved small bowel loop will be necessary

SECTION IV

EMERGENCIES OF GYNECOLOGICAL ORIGIN

GILBERT F DOUGLAS M D

33

Foreign Bodies in the Vagina and the Uterus*

Brief Anatomy of Vagina The vagina extends from the vulva to the uterus. It is situated in the cavity of the pelvis, behind the bladder and in front of the rectum Its walls are ordinarily in contact and its usual shape on transverse section is that of the letter H the transverse limb being slightly curved forward or backward, while the lateral limbs are somewhat convex toward the median line. It is constricted at its beginning, becomes dilated medially and is narrowed near its uterine extremity It surrounds the vaginal portion of the cervix uteri a short distance from the os, its attachment extending higher up on the posterior than on the anterior wall of the uterus The fact that the attachment of the vagina to the cervix is above the external os causes the formation of a recess between the cervix and the vaginal wall known as the vaginal fornix, this is divided into the anterior and posterior as well as the right and left portions the latter designated as the right and left lateral fornices

* Appreciation is expressed for assistance in the preparation of this Chapter to George Capers Douglas, M.D., and Sarah Frances Douglas, B.S., B.A., M.S., M.T

VAGINAL RELATIONS The upper part of the anterior wall of the vagina is in relation to the base of the bladder being separated by lax connective tissue Lower down the middle line of the anterior wall and closely joined to it is the urethra The upper part of the posterior wall near the middle line is covered for 6 mm. (¼ inch) or more with peritoneum which forms the anterior wall of the rectovaginal pouch of peritoneum, the pouch of Douglas. The vaginal orifice is near the separation of the rectum and vagina interposed between them is a mass of fibrofatty tissue called the perineum and perineal body

THE MUSCULAR COAT The muscular coat consists of two layers an external longitudinal which is far the stronger and an internal circular layer The longitudinal fibers are continuous with the superficial muscular fibers of the uterus The strongest fasciculi are those attached to the rectovesical fascia on each side The two layers are not distinctly separable from each other but are connected by decussating fasciculi which pass from one layer to the other Above the triangular ligament the fibers are nonstriated in the region of the ligament they show striations In addition

to this the vagina at its lower end is surrounded by a band of striped muscular fibers, the sphincter vaginae.

Brief Anatomy of the Uterus: The uterus is the organ of gestation, receiving the fecundated ovum in its cavity retaining and supporting it during the development of the fetus and becoming the principal agent in its expulsion at the time of parturition It is a hollow muscular organ The nonpregnant uterus is contained in the cavity of the pelvis between the bladder and rectum It is rarely placed exactly in the midline but inclines to one side or the other more often to the left than to the right. The walls of the organ are extremely thick. The uterus is movable as a whole and the body of the uterus is movable upon the neck Its position varies with the condition of adjacent parts especially the bladder and rectum The cervix is more firmly fixed than the body and fundus and hence the latter vary more in position than the former Normally in an erect individual, with the bladder and rectum empty the external os is at the level of the upper surface of the pubic symphysis and in the frontal plane passing through the ischiatic spines. The long axis of the uterus is directed forward and upward and is angled where the body and the cervix join. Hence, normally with the bladder empty the uterus is anteverted and anteflexed. If the bladder is overdistended and the rectum is empty the uterus is pushed strongly backward so that its long axis corresponds to the long axis of the vagina in other words it is retroverted

In the virginal state the uterus is pear shaped, flattened anteroposteriorly It is retained in its position by the round and broad ligaments on each side and projects into the upper end of the vagina below Its upper end or base is directed upward and forward its lower end, or apex, downward and backward in the line of the axis of the inlet of the pelvis It, therefore, forms an angle with the vagina, since the direction of the vagina corresponds to the axis of the cavity and the outlet of the pelvis. The nonpregnant adult uterus measures about 7.5 cm (3 inches) in length, 5 cm. (2 inches) in breadth at its upper part, and nearly 2.5 cm (1 inch) in thickness, and it weighs from 30 Gm (1 ounce) to 45 Gm (1½ ounces) It consists of two parts (1) An upper and larger portion, consisting of the body and fundus and (2) a lower smaller and cylindrical portion, the cervix

The Cavity of the Uterus The cavity of the uterus is small in comparison with the size of the organ because of the great thickness of the wall. That portion of the cavity which corresponds to the body is triangular flattened from before backward, so that its anterior and posterior walls are closely approximated, and having its base directed upward toward the fundus. At each superior angle is a funnel shaped cavity At the inferior angle of the uterine cavity is a small constricted opening smaller and more nearly circular than the external os uteri the internal orifice of the uterus, or internal os uteri which leads into the cavity of the cervix

The Cavity of the Cervix or Cervical Canal The cavity of the cervix or cervical canal extends from the internal os uteri to the external os uteri It is somewhat fusiform flattened from before backward, broader at the middle than at either extremity and communicates below with the vagina. The wall of the canal presents anteriorly and posteriorly a longitudinal column from which proceed a number of small oblique columns giving the appearance

of branches for the stem of a tree hence the name uterine arbor vitae.

THE MUSCULAR COAT The muscular coat forms the chief bulk of the substance of the uterus. In the unimpregnated state it is dense, firm, of a grayish color and cuts almost like cartilage It is thick opposite the middle of the body and fundus, and thin at the orifices of the fallopian tubes. It consists of bundles of unstriped muscular fibers, disposed in layers intermixed with areolar tissue, blood vessels, lymphatic vessels, and nerves The muscular tissue is disposed in three layers external, middle, and internal.

THE UTERUS AT DIFFERENT AGES The uterus of the fetus is in the abdominal cavity projecting above the brim of the pelvis. The cervix is considerably larger than the body At birth the cervix is larger relatively than in the adult there is no distinct os distinguishing the cavity of the body of the uterus from the cavity of the cervix, and "the arbor vitae extends throughout the whole length of the uterus "

FOREIGN BODIES

From a review of the anatomy of the vagina and of the uterus we can see that there are possibilities of these organs retaining any foreign bodies that may be introduced into them. There are instances that shall be related where foreign bodies were introduced into the vaginal canal of very young persons where the hymen remained intact. These may find a place of rest for a length of time before irritation becomes marked, and even when a sudden discharge of a bloody nature is seen a foreign body may not be suspected. Due to the musculature of this organ where there might be a certain amount of contractility present, the foreign body *might* move from one point to another Within the uterine cavity with this musculature (being rather thick and forceful in contractility) there is reason to believe that the foreign bodies might be displaced and gain entrance into the walls and migrate to foreign locations A case will be cited

These two organs, the vagina and the uterus are quite resistant to foreign bodies and can withstand a considerable amount of trauma without a great degree of pathologic involvement.

Underlying Reasons for Foreign Bodies in the Vagina and Uterus. Fundamentally the presence of any foreign body in any of the body's orifices may be considered under the following (1) Mental or psychic exaggerations or instability (2) Self-investigation or intentional (3) Carelessness or ignorance. (4) Accidental causes Individuals from the first category are seen frequently in mental institutions. Such mentally deranged persons will push any conceivable type of foreign object into their body for reasons which are mostly "figments of the imagination." The author recalls such an instance of an inmate of a state hospital. This patient was admitted and the vagina found to be completely packed with thirty hairpins. At emergency surgery we removed these pins, but it was impossible to obtain any good reason for the patient's action even for her own satisfaction.

It is entirely probable that many of the larger objects recovered from vaginas were placed there as an attempt at masturbation, particularly in persons who are inclined to be a bit erotic in their behavior This is a likely cause in some of those who did this, they said, "for no reason."

Self investigation and intentional reasons for such behavior are almost obvious

Secondly the repair of any tissue structure damage sustained in the incident is a proper consideration. Repair of perforations investigations of associated and attached peritoneal involvement, suturing of lacerations, etc. are all part of this phase of the treatment.

Next in importance is the treatment of any secondary infection or inflammatory process which may have developed since the incarceration of the object. Vaginitis endometritis peritonitis pelvic abscesses etc would all fall into this category The use of urea crystals in conjunction with sulfathiazole (penicillin and antibiotics with blood) in the treatment of pelvic abscesses and encapsulated pelvic inflammatory conditions has given heartening results particularly with an underlying neisserian salpingitis

Lastly therapy must treat not only the condition itself but notice also must be paid to the patient. Any basic defect in behavior or mental faculties as well as a temperary maladjustment of her personality must be frankly recognized by the physician and advice given the patient accordingly The removal of a symptom without proper deference to the basic disease or maladjustment is merely a method of postponing a recurrence of the same fate which would have been met at this time, had not surgical facilities been available.

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34

Management of Genital Tract Hemorrhage in the Female

Foreword. Physiology defines a tissue as an aggregation of similarly specialized cells united in the performance of a particular function In any body a tissue is normally confined by its mesenchymal elements within certain limits for the performance of its function. Examples are kidney tissue, lung tissue blood tissue thyroid tissue, adrenal tissue etc. Various tissues for the exercise of specific functions for the individual body (host) of an animal (or plant) are organized into highly complex patterns called organs That body which is served by a concatenation of the functions of its various organs is called an organism

Blood tissue is unique inasmuch as it is the only fluid circulating tissue, ubiquitous in the organism which contains certain cellular elements essential to the normal physiology of animal economy Blood is vital to the function of every organ and to the survival of the organism of which each organ is a part. It is that tissue which is the *sine qua non* of life itself

Definition Bleeding, or hemorrhage implies any abnormal escape of blood tissue from its vessels whether it is profuse or slight It is an aberrant process hostile to the function of every organ of the body and therefore inimical to the normal processes of the organism Aside from the periodic bloody discharge which characterizes normal menstruation, *hemorrhage should always be regarded as an indication of abnormality* It demands immediate attention undelayed, orderly investigation, and adequate measures to combat the cause control the flow and replace the loss. Failure to observe this axiom invites tragic consequences Hemorrhage conduces to shock Nothing creates more consternation or is a greater test of the skill, resources, and equanimity of the surgeon than sudden and violent hemorrhage Nothing provides for him more consolation than serious bleeding promptly and effectively controlled It is an axiom that it is more salutary to save blood than to replace its loss by transfusion

Genital Bleeding in Women In the female from puberty through the childbearing period and beyond the menopause anomalous hemorrhage from the genital tract is considered one of the chief symptoms of dysfunction or disease The bleeding may be external and revealed, or "frank " or it may

be internal or "concealed." The conscientious physician reflects both his sense of moral responsibility and his diagnostic keenness when he searches for its cause and promptly institutes treatment.

The origin of any bleeding from the female genitalia is disclosed only by methodical scrutiny In Table I are outlined the causes which are mainly responsible for bleeding from the external genitalia These become apparent during the most casual routine examination or inspection of the parts

TABLE I

THE CAUSES OF HEMORRHAGE FROM THE EXTERNAL GENITALIA

I *Vulvar Hemorrhage*	*Symptoms*
A. Trauma. B Varicosities. C. Infections. D Erosions. E. Ulcerations. F Malignant tumors.	Those of the causative factor The amount of bleeding is variable.

In general, treatment of these conditions (Table I) involving the external genitals is a local process, with the exception of infection, in which the use of antibiotics may be indicated, and of malignancy the treatment of which may necessitate the institution of all of the measures commonly employed in the eradication of cancer

Various factors responsible for genital bleeding, unassociated with pregnancy may develop during the menarche, the climacteric, the menopause, the intervals between these three or during the postmenopausal period. Details concerning the management of these lie beyond our present scope. The underlying *causes* of such bleeding, however are of too great importance to warrant their omission from the text.

It must here be emphasized that practical and rational treatment of any morbid process in the body depends first upon an accurate diagnosis of its etiology In medical practice a precise anatomic or pathologic diagnosis is not always achieved. The physiologic processes of the organism do not invariably follow mathematics-like formulas. Between normal function and any pathologic deviation from what is considered normal lies the sometimes indiscernible margin between health and disease. In the accurate definition of this border the scrupulous physician often encounters a challenge to his art and to his science.

The genital organs of women, like other systems of the body are often profoundly affected by constitutional changes arising from disorders elsewhere in the body The complete gynecological examination is therefore not limited to that which concerns only the contents of the pelvis A careful investigation of the other body systems is equally important. Woman is noted for her unwitting disposition to attribute solely to her pelvic organs even the most remote and unrelated symptoms[1] This fact often provides the facile inducement which misleads inexperienced or unwary physicians into the performance of unnecessary and fruitless gynecological procedures

In Table 2 are included the chief constitutional disturbances with which bleeding from the *nonpregnant* uterus is frequently associated. It will be observed that these conditions often are accompanied by excessive or prolonged menstrual bleeding (menorrhagia)

Local or *anatomic* (pelvic) causes of bleeding from the nonpregnant uterus are included in Table 2B For accurate classification of etiologic factors the

TABLE 2A.
HEMORRHAGE FROM THE NONPREGNANT UTERUS
Causes Often Menorrhagic in Tendency

Uterine Hemorrhage (Nonpregnant)	*Onset*
A General Causes (Constitutional) 1 Poor general health. 2 Acute or chronic organic disease. a. Infections b. Alcoholism 3 Tropical climate. 4 Circulatory system a. Blood dyscrasiae. b Cardiovascular disease. 5 Nervous system. a. Psychoses. b Neuroses.	Bleeding often revealed as a prolongation of menstrual flow Treatment of these conditions is usually medical and should be directed at the primary cause.

TABLE 2B
HEMORRHAGE FROM THE NONPREGNANT UTERUS (CONTINUED)
Causes Often Menorrhagic or Menometrorrhagic in Tendency

Uterine Hemorrhage (Nonpregnant)	*Onset*
B Anatomic or local causes. 1 Acquired. a. Trauma. b Displacements (puerperal) c Benign cervical lesions. 2 Physiologic. a. Menopausal. b. Subinvolution 3 Tumors. a Benign (adenoma of endometrium, endometriomyoma fibromyoma small cystic ovarian neoplasms) b Malignant (carcinoma or sarcoma of vagina or uterus. Chorioepithelioma) c. Retention cysts (ovarian follicle cysts. Endometrial glandular cysts) 4 Infections. a. Adnexitis. b Metritis. c Endometritis.	May be insidious. Patient may notice "spotting" between periods, or prolongation of menstruation or both An accurate history is essential Treatment is either medical or surgical, depending upon the cause

need for meticulous examination is emphasized The history carefully elicited, provides information which often enables the examiner to discriminate between significant facts and irrelevant information

Rational approach to the treatment of hemorrhage of obscure etiology involves the necessity of eliminating those factors which perhaps unrelated to the true cause of bleeding in a given case may be capable of producing in another

case the identical symptom hemorrhage

From the foregoing tables it is obvious that not all episodes of genital bleeding constitute indications for surgical management. It becomes also apparent (Table 2A) that the internist or psychiatrist is best qualified to treat certain cases in whom bleeding is discovered to be secondary to constitutional disease

These anatomic causes of bleeding (Table 2B) however may be due to acquired lesions, or to the physiologic changes which accompany pregnancy or senescence or to neoplastic or inflammatory disease These lie essentially within the realm of gynecology and/or obstetrics

Acquired causes of bleeding such as those concerned with *trauma*, are immediately discernible upon examination. Rupture of the hymen, sometimes followed by excessive hemorrhage is a typical example The treatment of these local injuries is usually obvious *Displacements of the uterus* especially those of the puerperium are not an uncommon cause of blood loss Correction of the malposition, aided by a suitable pessary if necessary may be expected to relieve the condition. *Benign cervical lesions* are exposed by the use of the vaginal speculum One must never with the naked eye attempt to distinguish benign from malignant changes The vaginal and cervical smear and microscopic scrutiny of tissue removed at biopsy provide the safest and surest means of differentiation *Erosions* constitute the commonest benign lesion These respond well to the local application of the cautery

Of the *physiologic* conditions in women the commonest cause of excessive uterine bleeding is that due to altered hormonal influences of the *menopausal* period. These functional disturbances depend upon endocrinopathic origins Their rational treatment depends upon the variable conditions encountered in each individual *Subinvolutional* causes of bleeding are elicited both by history and examination. Ordinarily they respond promptly to the indicated therapy The rare exception is chorioepithelioma (see under Hydatidiform Mole)

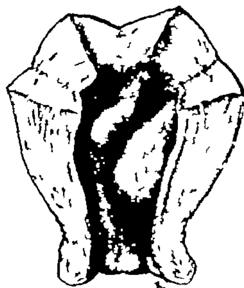


FIG. 1 Submucous fibroid and polypoid fibroid coexistent in the same uterus.

Tumors of benign origin are often causes of hemorrhage *Fibroid tumors* especially if submucous are frequent offenders, *Polypoid fibroids* have a tendency to bleed freely themselves often with an accompanying necrosis (Fig. 1) *Uterine adenomyosis* is an infiltrating process affecting the myometrium and is sometimes associated with (endocrine) *endometrial hyperplasia and polyps* (Fig 2) Pelvic *endometriosis* may similarly be associated with it. *Cervical polyps* generally a benign source of irregular bleeding, should be differentiated from those types

previously mentioned (Fig 3) The *ovarian neoplasms* produce or are associated with various hormonal changes

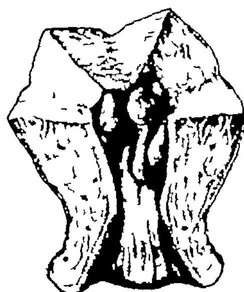


FIG. 2. Endometrial polyps.

Pelvic infection is noted for its tendency to produce bleeding

A diagnosis, based upon careful clinical investigation and microscopic examination (biopsy and smear) will usually indicate if the treatment is to be medical or surgical or both The estrogens, often advocated as a defense against the secondary vasomotor nervous, and other subjective symptoms of physiologic menopausal endocrine readjustment, are sometimes more psychic in effect than otherwise Their continued use in any case cannot be justified They produce a proliferative stimulation of the endometrium, and thus invite excessive uterine bleeding The carcinogenic properties of estrogen are open to speculation

When bleeding of doubtful origin is

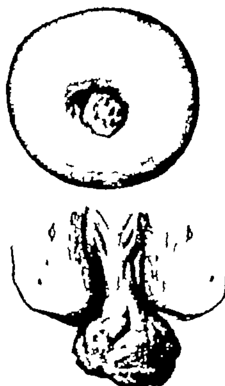


FIG. 3 Benign cervical polyp.

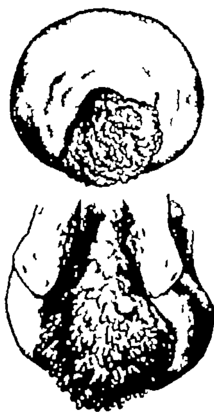


FIG. 4 Carcinoma of the cervix.

unduly prolonged especially when hemorrhage as a result of estrogen therapy is unlikely diagnostic curettage is recommended for the recognition of the possible existence of *adenocarcinoma of the uterine body*

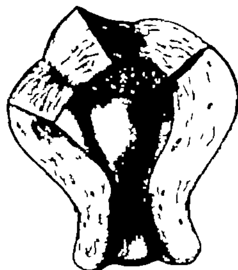


FIG. 5 Early adenocarcinoma of the uterus.

Foremost among the malignant tumors of the uterus (Fig 4) is *cancer of the cervix* Cancer of the uterine body (Fig 5) is less common. It is estimated that cervical cancer is encountered in eight out of nine cases of uterine malignancy The neoplasm may develop high in the endocervical canal and thus escape early detection by ordinary inspection. The exact nature of any cervical lesion can be accurately determined only by histologic study

Exploration of the whole interior of the uterus and microscopic examination of its contents (curettings) should be considered obligatory in the study of every nonpregnant patient of cancer age with inexplicable passage of blood from the interior of the uterus!

During pregnancy bleeding from the uterus is not invariably due to the existing gestation It is known that pregnancy may occur during or following the development of some other (*coexistent*) process which involves the genitalia. Likewise the reverse may be true. The possible exception to this is choriocarcinoma, which depends for its development upon the presence of trophoblastic elements which may well have had their origin in a previous gestation unrelated to the present pregnancy

In Table 3 are enumerated the conditions associated with genital hemorrhage which may also *coexist* with pregnancy The "pseudomenstruation" included in this Table may be an evidence of placentation, the flow being due to the escape of blood (sometimes profuse) from a uterine sinus following invasion of the latter by normal villous development. It may similarly be evidence of normal (endometrial) bleeding from the decidua vera before the growing embryo obliterates (third month) the uterine cavity

Endocrine influences may be responsible for bleeding as a result of either insufficient decidual development (*hypoplasia*) or overstimulation of this bed for embryonal nidation (*hyperplasia*) Either may cause hemorrhage in early pregnancy and each is responsible for some abortions

Deciduitis signifies an inflammatory condition, often due to infection, which may also produce bleeding and abortion. The source of such infections is usually from without (instrumentation, etc) Treatment should include rest and antibiotics

Pregnancy *per se* is by no means a contraindication to careful routine inspection of the cervix by means of a speculum. Under the influence of gestation such remarkable cervical changes

may result, however that great caution must be exercised even by the trained pathologist in the differential diagnosis of benign from malignant noninvasive lesions *A rash or erroneous diagnosis* may lead to the needless destruction of an unborn child, or to permanent and unnecessary sterilization of the mother!

Pelvic tumors are not rarely found co-existing with gestation. While their existence usually is discovered during the course of the examination of the pelvis early in pregnancy recognition of their presence may be delayed until external bleeding or other signs of abortion, or of labor appear At times the discovery of a pelvic tumor is not made until the postpartum period in which case its presence during the pregnancy may be questioned

Intramural and submucous fibroids have a greater tendency to produce bleeding and abortion than those of the subserous variety

Ovarian tumors are less likely than fibroids to be the cause of hemorrhage Dermoid cysts are more dangerous than cystoma especially during labor (rupture peritonitis) Ovarian neoplasms may undergo torsion at any time and thus become a cause of an acute abdominal emergency or during labor they may become a source of obstruction

Aside from their tendency to cause bleeding (abortion) and premature labor which demand attention in most cases no interference with the presence of benign pelvic tumors is indicated during the gestation

Chorioepithelioma is the *bete noire* of the obstetrician gynecologist, and pathologist It is a capricious tumor originating from chorionic elements, always invasive in tendency and sometimes extremely malignant In the latter instance it becomes the most rapidly metastatic tumor with which we have to deal To distinguish under the microscope the potentials of malignancy in an early case is often a challenge to the most experienced microscopist (see under Hydatidiform Mole)

Among the commonly encountered instances of bleeding from the internal

TABLE 3

GENITAL HEMORRHAGE

Causes Sometimes Coexisting With Pregnancy

Uterine Hemorrhage	*Onset*
A Pseudomenstruation B Endocrine influences. C. Hypertrophic deciduitis. D *Cervical lesions*, benign E. Carcinoma of cervix. F Pelvic tumors. G Chorio-epithelioma.	Usually diagnosed by examination early in pregnancy The history is important. Biopsy of all suspicious lesions will aid in the early detection of carcinoma. The speculum is an invaluable aid in diagnosis.

TABLE 4A

GENITAL HEMORRHAGE

Causes Directly Related to Early Pregnancy

Uterine Hemorrhage (Early pregnancy)	*Time of Onset*
A. Abortion. 1 Threatened (called Stage 1) Inevitable (*called Stage 2*) 3. Incomplete (called Stage 3) 4 Missed. B Moles. 1 Hydatidiform mole. 2. *Blood mole* C Extrauterine (ectopic) pregnancy 1 Cervical pregnancy	Usually manifest relatively *early* in pregnancy (First trimester)

genitalia are those which are *directly* related to pregnancy For teaching purposes such episodes of hemorrhage are classified as (1) those occurring during the early months of gestation (see Table 4A) and (2) those encountered late in pregnancy or during labor or following delivery (see Table 4B)

MANAGEMENT OF UTERINE HEMORRHAGE DURING EARLY PREGNANCY

Abortion The term abortion, in its strict medical connotation implies the spontaneous interruption of any pregnancy prior to the period of viability or before the end of the twenty-sixth week of gestation It is variously estimated that from ten to twenty per cent of all pregnancies terminate in abortion. Actually most of these occur before the formation of the placenta is complete (twelfth week) The fact that a large percentage of abortions are not hospitalized makes an accurate survey of its incidence difficult (Table 6)

Threatened Abortion (Stage 1) The process is invariably accompanied by uterine contractions, or "cramps," often followed by "spotting," or hemorrhage Usually the contractions and bleeding are associated In the initial stage the symptoms may at times be transient and subside without treatment, permitting the pregnancy to proceed to term. In practice, however treatment consists of bed rest, sedation, a bland diet, and estrogen (diethylstilbestrol, 25 mg. three times a day) until all signs subside The existence of ectopic gestation must be ruled out (*vide infra*) Other factors (see Table 3) which may cause bleeding must be considered.

Inevitable Abortion (Stage 2) If the above measures fail and the symptoms progress there may be alarming hemorrhage. A careful aseptic vaginal examination is indicated. Blood loss must be replaced by transfusion However until the cervix reveals definite changes (obliteration, retraction dilatation) which clinically convert the threat of abortion (Stage 1) into the inevitable or second stage of abortion, conservative treatment is recommended No attempt should be made during stage 1 to invade the uterine cavity or to stimulate contractions Profuse bleeding in certain of these cases appears to be the result of marginal choriondecidual separation. This may be temporary inasmuch as in many instances cessation of symptoms and healing take place spontaneously and following delivery at term no evidence of pathology can be demonstrated. During the episode of first stage bleeding, to avoid stimulation of the bleeding uterus, the vaginal tampon or pack is contraindicated.

Often, however in spite of all conservative measures, the cervix softens, its canal becomes obliterated, and the external os dilates These findings represent those of the second, or inevitable stage.

Incomplete Abortion (Stage 3) If in the spontaneous expulsion of the products of conception, the uterus is not entirely evacuated, the abortion (stage 3) is termed incomplete Hemorrhage in varying amounts is recurrent and persistent. It may be very profuse. Unless the offending material is expelled it must be artificially removed. The latter procedure and blood transfusion constitute the recommended treatment. Delay invites increased anemia and infection

Hydatidiform Mole: The bleeding from the uterus which harbors this potentially malignant neoplasm of the chorion at first often closely resembles

that of a threatened abortion Events not universally present in mole, but which, when present, tend to arouse or confirm suspicions of the true cause of the continued bleeding are (1) its persistence (2) untimely increase in the size of the uterus, and its doughy consistency (3) the escape of vesicles, (4) early exaggeration of any toxemic symptoms, and (5) abnormally and persistently high titer of chorionic hormone in the urine Ordinarily no evidence of the presence of a fetus is demonstrable in a mole either clinically or by x-rays

The effects of hemorrhage should be counteracted by blood transfusion whenever necessary Evacuation of the suspected tumor must be delayed until a positive diagnosis is made. Then its expulsion is encouraged by the employment of medical measures (oxytocics) and/or a cervical pack to induce uterine contractions Only if the uterus is no larger than a three months pregnancy should early instrumental curettage be attempted. *It should be most cautiously* and carefully performed and the mole completely evacuated at one sitting With sufficient cervical dilatation the ovum forceps and the finger are far safer than the curet because of the great danger of perforation of the soft, boggy myometrium Spontaneous abortion of the tumor is the recommended treatment since often the evacuation of the mass is accompanied by profuse hemorrhage With artificial interference additional hemorrhage is always to be expected. Blood for transfusion the oxytocics, and a *sterile gauze pack should invariably* be in readiness

Rarely and only when the diagnosis is indubitable and the tumor is of large size, hysterotomy should be considered The cervical pack and the intravenous administration of pitocin (1 cc in 500 cc of five per cent glucose or saline, twenty to forty drops per minute) will usually initiate contractions and expulsion. *It is wise to make certain the* uterus is completely and thoroughly evacuated (digital or manual exploration)

Follow-up precautions in every case of hydatidiform mole are imperative because of its tendency to malignant transformation (chorioepithelioma) In the absence of another pregnancy repeated choriogonadotrophin assays are indicated Diagnostic curettage for subsequent "subinvolution" or irregular bleeding with microscopic scrutiny of all the curettings, may reveal the presence of the tumor elements which confirm the presence of this neoplasm.

Table 4B

GENITAL HEMORRHAGE (*Continued*)

Causes Directly Related to Late Pregnancy Labor or to the Puerperium

Uterine Hemorrhage (Late pregnancy)	*Time of Onset*
D. Abruptio placentae. E. Placenta previa. F Low implantation of the placenta, or rupture of the cord or marginal sinus. G Rupture of the uterus. H Inversion of the uterus. I Postpartum hemorrhage 1 Placental stage. 2. Uterine atony 3 Retained secundines. (also placenta accreta or increta) 4 Lacerations of the birth canal 5 Hematoma.	Not usually manifest until relatively late in pregnancy or during labor or following delivery (Third trimester intrapartum, or post partum)

TABLE 5

PRINCIPAL CAUSES OF EMERGENCY OBSTETRIC HEMORRHAGE

Etiology	*Frequency (average)*	*Period of Gestation*	*Type of Bleeding*	*Mortality Rate*
A Abortion	10% 20%	1st trimester	Frank.	Rare in spontaneous.
B. Hydatidiform Mole	1 to 2,000	1st trimester	Frank.	5% to 10%
C. Ectopic Pregnancy	1 300	1st trimester	Mostly internal Some spotting.	2%-4%
D Abruptio Placentae	0.5% 1%	3rd trimester	Frank or concealed.	2% 5%
E. Placenta Previa	1 150	3rd trimester	Frank.	0.5% 1%
F Rupture of Uterus	1 2,000	Usually during labor or spontaneous.	Mostly internal.	5% (of all maternal deaths)
G Acute Inversion of Uterus	1 5,000	Before completion of 3rd stage.	External with Shock.	1% 10%
H. Postpartum Hemorrhage (Over 300 cc. from any cause)	1 4%	During or after 3rd stage.	External.	Extremely variable depends on cause.

These elements may be absent if the growth is below the level of the surface scraped by the curet. One must be aware that any mole may be (1) benign, (2) invasive but not cancerous or (3) invasive and malignant.

In a case in which there is grave doubt the conscientious pathologist will recommend hysterectomy In a patient under forty uninvolved ovarian tissue may be conserved.

Ectopic Pregnancy· This term is used to indicate any pregnancy which is not inside the cavity of the uterus The recognition of the condition is noted for its pitfalls often in spite of most painstaking procedures in diagnosis External bleeding may be slight, or even absent. The amount of internal (intra abdominal) hemorrhage, and the degree of shock which ensues following rupture of an extrauterine gestation, are in direct proportion to the length of the interval between the time of a diagnosis and that of operation The threat of rupture of the ectopic sac constitutes a grave menace to the mother s life The removal of the pathologic mass becomes a licit and mandatory procedure as soon as the diagnosis becomes reasonably certain. Adequate blood for transfusion must be available.

It is better to perform laparotomy in good conscience upon ectopic pregnancy and discover the diagnosis to be erroneous than to invite maternal death through irresolution and delay!

Cervical pregnancy is a form of ectopic pregnancy *in which* the ovum develops below the internal os but within

TABLE 6

CAUSES OF OBSTETRIC HEMORRHAGE IN EARLY PREGNANCY (INCLUDING ABORTIONS)

*An Analysis of 10,756 Consecutive Pregnancy Admissions.**

Cause	*Abortion*	*Ectopic Pregnancy*	*Hydatidiform Mole*	*Cancer of Cervix*
Number	756	32	5	2

*From the Obstetrical Unit Syracuse General Hospital State University of New York at Syracuse, New York.

the endocervical canal itself It may lead to early and profuse hemorrhage from rupture of the vessels concerned with the nutrition of the ovum It is a rare occurrence

In 10 000 consecutive pregnancy admissions (see Table 6) ectopic pregnancy was encountered thirty two times Following laparotomy recovery ensued in each of the thirty two cases True cervical gestation has not been encountered in the author's experience

Profound and too often tragic sequelae of sudden and torrential bleeding internal or external are doubtless most frequently observed in obstetric practice where hemorrhage takes precedence as the *leading cause of maternal death!*

In Table 5 are assembled the obstetric conditions held mainly responsible for sufficient bleeding to demand emergency and sometimes heroic measures of treatment.

MANAGEMENT OF UTERINE HEMORRHAGE DURING LATE PREGNANCY

Abruptio Placentae· *This expression is employed to designate accidental* antepartum bleeding due to the premature separation of a normally implanted placenta after the fifth month of gestation The degree of placental separation may be slight or complete It may occur before labor or during labor It may be associated with toxemia or trauma or may be obscure in origin. The ensuing hemorrhage may be frank, or concealed, or both The amount of blood lost depends upon the size of the uterine sinuses involved in the area of separation. It is the general concensus that the blood lost by placental detachment is chiefly maternal blood The ill effects of the accident upon the fetus are due to asphyxia.

The maternal mortality of abruptio placentae with internal (*concealed*) hemorrhage is six times as great as that observed in the cases in which the bleeding is external It is important to distinguish abruptio placentae from placenta previa and from rupture of the uterus The careful evaluation of history symptoms, and signs (see *Table* 7) and a painstaking physical examination are the most reliable guides to correct diagnosis One must likewise *consider the possibility* especially during labor of bleeding from the uterus which results from a mild degree of separation of a placenta which is implanted lower than usual (usually not serious) Rupture of the marginal sinus or of a vessel in the cord (*vide infra*) may also mildly simulate the first two of the above conditions. The total re-

TABLE 7

DIFFERENTIAL DIAGNOSIS

Condition	*Abruptio Placentae*	*Placenta Previa*	*Ruptured Uterus*
History	Often of trauma.	Irrelevant.	Often history of previous section, or D and C.
Onset	Stormy Usually accompanied or followed by labor	Uneventful, painless bleeding.	Sudden. Usually preceded by uterine contractions (labor)
Pain	Usually present, especially if bleeding is concealed.	No pain.	Calamitous at onset.
Symptoms	Marked in concealed hemorrhage Less so in frank bleeding.	May be none except painless frank bleeding.	Urgent. Acute emergency
Hemorrhage	Frank or concealed, or both.	Always frank.	Most internal, some external. Signs of shock.
Inspection	Visible evidence of discomfort, anxiety or pain.	No evidence of discomfort or pain.	Marked apprehension. Impending shock.
Palpation	Uterus irritable or tonic. Fetus may not be felt if bleeding is concealed.	Uterus relaxed. Normal. Fetus palpable.	Uterus smaller Fetus easily felt in abdomen, if rupture is complete.
Fundus	In concealed hemorrhage rises.	No change.	Lower
Auscultation	Normal, variable or absent heart tones.	Normal findings.	Fetal heart beat absent usually
Vaginal Examination	Presenting part accessible to examining finger	Dangerous! May encounter only placenta over os!	Nothing in pelvis. Uterine rent may be palpable
Bag of Waters	Tense or bulging if palpable.	Not felt if previa is complete. Care!	Absent.
Presenting Part	May be in pelvis.	High or floating.	Absent.
Urinalysis	May show evidence of toxemia.	Irrelevant.	Irrelevant. Fresh blood in urine may denote associated bladder trauma.

corded number of the latter two epi sodes (Table 8) was 11 in 10 000 con- secutive cases reviewed in our series The bleeding which results in these two in- stances is of fetal origin and has been known to result in fetal death due to exsanguination.

The relationship of maternal toxemia cardiovascular disease, trauma and psy chic or emotional influences as factors in the production of accidental hemor rhage is of significance The reported statistical frequency of premature pla cental separation is variable (see Tables 8 and 9)

Hemorrhage in abruptio placentae may be mild, moderate or severe The blood loss may be revealed (frank) or concealed (Figures 6 7 and 8) It should be a rule that generous blood transfusions be given as soon as practic able dextrose (ten per cent) in normal saline being administered while the blood is being made available. One should not withhold narcotics for the pain.

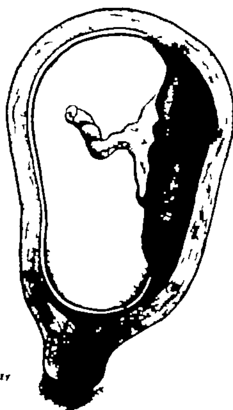


Fig. 7 Abruptio placentae complete. Hemorrhage internal and external.

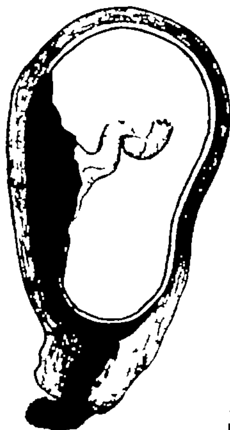


Fig. 6 Abruptio placentae Hemorrhage external.

Premature placental separation even of slight degree frequently invites the onset of normal and vigorous uterine contractions without excessive loss of blood. With separation of slight degree the fetal heart rhythm may not be ap- preciably affected If the os dilates early artificial rupture of the membranes (making sure to evacuate as much amniotic fluid as possible) permits the uterine muscle fibers to shorten en

hances their power of contraction re duces the caliber of the bleeding sinuses, and accelerates the first stage of labor Delivery from below is indicated as early as possible in the second stage (not force but art the baby needs to be considered)!

Abruption of moderate degree signi fies the same process with more placental separation more hemorrhage and more urgent sequelae A wavering fetal heart beat, increased maternal pulse rate rigid and persistently undilated cer

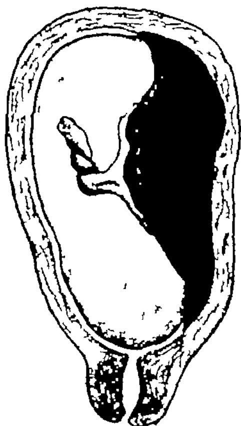


FIG. 8 Abruptio placentae complete. Hemorrhage internal (concealed)



FIG. 8A. Partial abruptio placentae. Internal hemorrhage moderate.

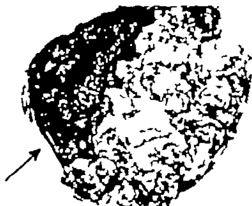


FIG. 8B Placenta, maternal surface, showing about one-third of its area previously separated.



FIG. 8C. Marked hemorrhage, concealed, in abruptio placentae.



FIG. 8D Couvelaire uterus. Specimen removed by hysterectomy

TABLE 8

CAUSES OF OBSTETRIC HEMORRHAGE IN *LATE* PREGNANCY DURING LABOR, OR IN PUERPERIUM

*An Analysis of 10,000 Consecutive Deliveries.**

Cause	*Abruptio Placentae (all degrees)*	*Placenta Previa (all types)*	*Rupture of the Cord or Rupture of Marginal Sinus*	*Rupture of the Uterus*	*Inversion of the Uterus*	*Post partum Hemorrhage (over 500 cc)*	*Placenta Accreta (attempted removal)*
No.	108	68	11	5	2	139	1
Approx. Frequency	1%	1 150	1 1000	1 5000	1 2000	1 4%	1 10,000

* From the Obstetrical Service Syracuse General Hospital Unit, State University of New York at Syracuse New York.

TABLE 9

SEVERE HEMORRHAGE DUE TO ABRUPTIO PLACENTAE AND PLACENTA PREVIA

*Incidence in 24,212 Consecutive Pregnancy Admissions **

Condition	*Number*	*Frequency*
Placenta Previa	117	1 206
Abruptio Placentae	128	1 189

**Combined admissions to the Memorial Hospital and General Hospital Obstetrical Units of the Medical Center State University of New York, Syracuse, N Y*

vix especially in a primigravida, discourages the hope of early delivery Blood loss must be replaced but forcible attempts to dilate such a cervix after rupture of the bag of waters, or rash methods instituted to hasten the onset or progress of labor invite only worse complications Laparotrachelotomy in some cases offers greater security to both mother and child Reasonable conservatism, in the hope of avoiding an unnecessary abdominal delivery is laudable Even in apparently desperate cases continuous transfusion, with artificial rupture of the membranes and evacuation of the amniotic fluid, frequently is followed by dramatically satisfactory results Labor in many instances promptly ensues and accelerates the full cervical dilatation required for completion of the delivery by forceps The continuous transfusion is an important safeguard against the anticipated shock invited by the expulsion from the uterus following delivery of an unpredictable amount of previously accumulated and concealed blood.

Rarely if the premature separation of the normally implanted placenta is extensive and the bleeding largely concealed, there follows increase in the size of the uterus (retained blood) increasing pain, and an overstretching and separation of the fibers of the uterine wall The extravasated intrauterine blood is forced by the firmly contracted uterus into the interstices of the muscle fibers (interstitial hemorrhage) This may cause sufficient damage to interfere seriously with the recovery by the womb of its normal tone after the operation of delivery (couvelaire uterus) A true couvelaire uterus is seldom observed.

After delivery especially in any case of premature placental detachment, one should remain alert to the possibility of misbehavior (relaxation) of the uterus The frequency of postpartum hemorrhage in these cases is notable. Constant vigilance, the oxytocics (after not before delivery) bimanual compression of the uterus and occasionally the firm uterine pack (see under Postpartum Hemorrhage) are the most efficient combative measures against this added complication. Gentle and *persistent massage* of the fundus aids in securing and maintaining contraction of the empty and intact postpartum uterus. This provides the greatest measure of assurance of minimal postpartum blood loss Such massage, supplemented by the slow intravenous administration of pitocin (1 cc. [15 minims] in 500 cc of glucose or saline) is equally important to sustain tonic uterine counterpressure against the intrauterine gauze pack which is sometimes employed

Following the emergency procedures instituted in any case of severe abruptio there is a tendency toward the development of anuria (renal arterial spasm) This is a serious sequel, particularly if the anuresis is complete (lower nephron lesion?) It is considered a mistake to supply intravenous fluids too generously in the presence of this concurrence Caudal anesthesia, continuously administered before cortical necrosis results may relax the renal spasm

It has been observed also that in abruptio the coagulability of the blood at times undergoes such alteration (toxin?) that bleeding elsewhere in the body may ensue. In such instances fibrinogen and vitamin K should be administered as a beneficial therapeutic measure

Placenta Previa In this condition the site of attachment of the placenta to the uterine wall involves all, or a part of, or the rim of the internal os of the uterine cervix.

In the latter weeks of pregnancy and usually before the onset of labor a normal and physiologic dilatation of the internal os accompanies the normal obliteration of the cervical canal. In placenta previa some degree of separation of the adjacent placenta usually follows This is inevitably accompanied by painless external bleeding mainly from the uterine sinuses in the area of placental separation.



FIG. 9 Complete placenta previa.

Didactically we speak of placenta previa centralis or complete (covering the entire internal os) lateralis or partial (partially covering the os) and marginalis (at the margin or periphery of the internal os) Clinically each type (Figures 9 10 and 11) usually manifests its presence by a common sign, hemorrhage. The bleeding is noted for its painless onset before the expected date of labor In some cases this may not occur until the onset of labor itself The type, *i.e* the exact relation of the placenta to the os bears no relation to

the amount of hemorrhage Severe and alarming hemorrhage due to placenta previa was encountered in 117 cases during 24,212 consecutive pregnancy admissions (see Table 9)

It is a dreaded complication, with a high maternal mortality It is even a greater threat to the life of the fetus (prematurity)



FIG 10 Partial placenta previa.

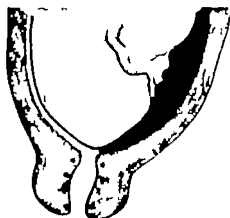


FIG. 11 Marginal placenta previa.

As in the treatment of all emergencies accompanied by hemorrhage prompt and liberal blood transfusion in placenta previa is perhaps the prime factor in the conservation of life

Treatment next involves a dual aim, the protection of the life of the mother and the conservation of the life of the unborn (often premature) child The problem becomes that of converging these two aims with such delicacy of judgment and conservatism as to warrant a hopeful outlook for both. To interpose untimely and rash interference in placenta previa imposes great risk upon the life of the mother and greater risk upon the life of the premature baby

In any case the patient should be at bed rest, preferably in a well equipped, well manned obstetrical department. The initial spontaneous bleeding especially if the cervix has been unmolested by inquisitive, predatory fingers or by instrumentation, is usually very moderate It serves as a warning of the condition Other causes (*vide supra*) may be responsible for the bleeding In most instances of placenta previa the first hemorrhage signifies the immediate need of rest and adequate blood transfusion It is important to restore and to maintain (blood count, hematocrit, etc) the maternal blood picture at a normal level Meanwhile other details concerning aseptic preparations (for examination or operation if the need becomes urgent) are deliberately made If the pregnancy is not sufficiently advanced to provide reasonable hope for (*previable*) fetal survival, and the hemorrhage is not persistent, expectant treatment under vigilant supervision is justifiable Usually the initial bleeding lessens under this regime and often ceases altogether

Ordinarily under these circumstances, one may permit the proposed diagnostic internal examination to be deferred one to three days It is then performed in the operating room and only after the maternal blood count is restored to

normal, when every facility for abdominal operation and additional transfusion is ready and trained assistants are at hand gowned and gloved, to aid in any emergency In our Medical Center these precautions constitute what is termed the "double set up" for pelvic examination.

First, the cervix is carefully exposed and examined with the aid of a speculum (other lesions) after which the instrument is withdrawn The gloved fingers are then inserted cautiously into the vagina in order to palpate gently the lower segment It is an inquisitive attempt to locate the site of the placental mass or to palpate the presenting part through the lower uterine segment. If the thickness of the tissues suggests the presence of placenta a presumptive diagnosis of placenta previa is justified If the fetus is previable the external os and cervical canal are scrupulously *avoided* The patient is returned to her bed In her case continued observation and expectant treatment are recommended. The object here is to prolong the pregnancy in the interest of the unborn child.

X-rays employing the so-called soft tissue technic, may be an aid in visualizing the location of the placenta. The procedure has its limitations and is not always reliable

If the case is one in which the baby is viable, and the pregnancy is approaching term, the examination is similarly conducted Often in these instances the external os admits a finger for gentle and most cautious exploration of the cervical canal. This facilitates more accurate diagnosis The digital examination discloses the placental location if it is in proximity to the internal os Great care must be exercised to avoid further placental separation and its resultant blood flow Quantities of blood for replacement must always be available

If the placenta is discovered completely covering the internal os, delivery of the *viable* child is accomplished at once by abdominal section as soon as the patient can be anesthetized and made ready Under these conditions procrastination is contraindicated

In a primigravida near term, especially if there is bleeding and the presenting part is unengaged, once the diagnosis of placenta previa is confirmed, abdominal delivery also affords the best prognosis to both mother and child. In these instances the precise relation of the placenta to the internal os is of more academic than practical importance

In multiparae particularly those already in labor in whom some cervical dilatation is found if the location of the placenta is marginal, or if it only partially covers the os, simple rupture of the amniotic sac to drain the fluid may permit the presenting part to descend sufficiently to tamponade the bleeding effectively from above This is a fortunate circumstance, and labor in such cases frequently proceeds The pressure upon the placenta of the presenting part in this manner prevents further undue blood loss Vigilance, however must not be relaxed. This type constitutes about one half of the cases of placenta previa Continued hemorrhage, due to failure of the presenting part to descend, may necessitate abdominal delivery Other measures of treatment through the vagina are usually meddling, manipulative procedures They *invite* more hemorrhage and more trauma to a soft, vascular spongy and easily lacerated lower segment and cervix. They have little to recommend them in un-

infected cases. The daring or the manual dexterity of the operator reflected by reports of an unusually low incidence of abdominal delivery in any series of cases of true placenta previa, is a dubious distinction.

After delivery in the presence of placenta previa failure of an intact but boggy "passive" lower segment to constrict the uterine sinuses of the placental bed invites postpartum hemorrhage. Alertness and the prompt insertion of a firm vaginal pack against the lower segment will control this Such a pack should be removed after twenty four hours Routine packing properly performed, has much to recommend it as a safeguard against this threat of post partum lower segment hemorrhage

In recapitulation it may be presumed, at first that apparently causeless and painless uterine bleeding during the last trimester of pregnancy is due to placenta previa. *Such a presumption must be* confirmed or disproved by a careful subsequent pelvic examination. This is to be performed only after adequate treatment of the hemorrhage and after other safeguards have been observed The urgent occasion for initial action is the hemorrhage not the diagnosis!

If the diagnosis of placenta previa is confirmed the proposition becomes resolved into (1) the conservation of the lives of the mother and baby by expectant but guarded treatment until the period of viability Liberal blood transfusions of the mother may be required at intervals during this time (A case of the author's was transfused thirteen times in ten weeks In the thirty-sixth week she was delivered by cesarean section of a healthy viable child) Then (2) normal delivery of the viable child is invited by simple rupture of the membranes, provided they are readily accessible, *without other manipulative or instrumental interference* If persistent bleeding is not controlled by the pressure of the presenting part, or if instead of membranes the placenta covers the internal os (3) delivery should be accomplished by cesarean section.

If violent hemorrhage occurs during the aseptic pelvic examination, conducted under the "double set-up" precautions mentioned above, a firm pack against the cervix is permissible as a temporary measure Its object is to decrease the blood loss during the interval between its insertion and the immediate performance of cesarean section, for which all preparations were previously made in anticipation of the emergency

Acute Inversion of the Uterus: This is one of the rare causes (Table 10) of postpartum hemorrhage and shock. The evidence of shock is out of proportion to the degree of bleeding. In spite of the reported infrequency of the condition the author has attended five cases in which the accident had occurred. In two of these the inversion (Fig 12) apparently had happened spontaneously In the remaining three the mishap may have accompanied untimely and imprudent attempts (during uterine relaxation) to express manually from the uterus the already separated placenta.

In each instance the placenta had been delivered before the inversion was recognized. In no case was it disclosed that traction upon the cord had contributed to the condition Following early and successful reposition of the uterus prompt recovery followed in each case

The diagnosis of inversion is based upon (1) the bleeding (2) the cup-like depression or crater over the symphysis where the fundus normally should be palpated, and (3) the increased

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maternal pulse rate and disposition toward syncope and shock Inspection and vaginal examination discloses the round velvety grotesquely purple red tumor whose outer surface before the accident was the inner surface of the uterus The inversion may be partial or complete

The management of the acute episode consists of (1) immediate transfusion and other supportive measures to combat impending shock and (2) prompt steps to restore the uterus to its normal state. In the author s experience it became manifest (A Fig 12) that



FIG. 12. Puerperal inversion of the uterus. A. Cervical cuff of the portio vaginalis. B. Inverted fundus uteri.

(1) the vaginal cuff of the cervix cannot participate in the inversion, and (2) successful reposition of the inverted body of the organ depends upon manual manipulation, in the form of taxis. The direction of the taxis must be upward in the axis of the pelvis. The taxis must be applied against the uterine wall, adjacent to the periphery of the cervical ring.

Under appropriate anesthesia the whole hand is inserted into the vagina upward between the inverted uterine mass and the vaginal wall. The fingers seek and identify the inferior margin of the cervical cuff which lies above and is concealed by the rounded bulk of the vaginal mass Because of its anatomical relation to the vaginal vault (Fig 12) this structure (cervix) invariably hangs like a short curtain around the entire periphery of the contraction ring (internal os) which encircles and constricts the neck of the inverted uterus Eight or more cervical clamps are employed to grasp at various points the entire circumference of the cervical curtain. The application of the clamps is rather evenly distributed around the entire edge of the cervical cuff Upward taxis with the finger tips of the internal hand is then exerted against the side wall of the inverted uterus at one area adjoining the periphery of its constricting collar As the finger tips of the internal hand thus begin to exert steady upward pressure against the uterus at one point the external hand of the operator exerts downward traction upon the handles of one or two of the clamps which are attached to the cervix at a point which precisely corresponds to the point of upward pressure exerted by the internal fingers The maneuver thus combines gentle pushing (against the uterus) and pulling (upon the cervix) simultaneously The internal manipulation or taxis is not unlike that employed externally in the manual reduction of an abdominal hernia Undue force is inadvisable At first the maneuver seems fruitless, but after an interval, aided by the relaxation provided by the anesthetic, the tension of the constricting band above the inversion slowly yields to the upward pressure at the point of applica

tion When the first evidence of beginning uterine reposition becomes apparent the internal fingers are shifted laterally a centimeter or two to a new position Simultaneously the external hand is also shifted to the handles of the previously applied cervical clamps which correspond to the new position of the internal fingers The upward pressure of the finger tips in this new position against the uterus, accompanied by downward traction upon the cervix, is repeated. More uterine reposition follows. The same procedure is continued until the entire uterus is restored to its normal state The cavity of the reposited uterus is then securely packed with gauze to guard against the possibility of a spontaneous recurrence of the inversion The pack is removed after twelve to twenty four hours

In the experience of the author no case has been encountered in which the placenta remained still attached to the uterus at the time of the accident. It has been recommended by some that reposition in these instances be accomplished before the afterbirth is removed manually (hemorrhage) The presence of the attached placenta inevitably increases considerably the bulk which must be maneuvered upward through the constricting collar of the internal os It appears, therefore that after blood transfusion is started and before replacement is attempted, the feasibility of the operation would be facilitated by previous manual removal of the placenta

Rupture of the Cord Rupture of the Marginal Sinus When the placental attachment is low enough (Fig 13) to encroach upon the lower uterine segment, but is not adjacent to the internal os it may give rise to some bleeding during labor Such "low implantations" of the placenta are seldom dangerous either to the mother or fetus and are not to be confused with placenta previa. Low implantation of the placenta is of relatively common occurrence

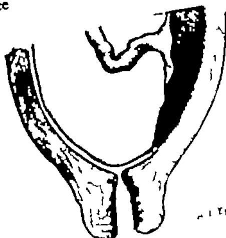


Fig. 13 Low implantation of the placenta.

With such low placental implantation, however any velamentous vessels may be in such close relation to the internal os (vas previa) that the pressure exerted upon them by the presenting part may interfere with fetal circulation, or even cause their rupture with that of the membranes If rupture of such a vessel occurs the external bleeding which ensues is fetal not maternal, in origin. This is a most unusual circumstance. It rarely may be the cause of fetal death by exsanguination

Likewise during labor incidents have been observed involving rupture of the marginal sinus of the placenta. Here too the resultant escape of blood is of fetal origin

The correct diagnosis of these conditions is usually made after delivery by careful inspection of the secundines Their occurrence also should not be included among the statistics concerning abruptio placentae or placenta pre-

via with which they have in common only the single symptom of external bleeding (hemorrhage)

The incidence of the latter two accidents in the production of *intrapartum* hemorrhage is infrequent (see under Abruptio Placentae)

Rupture of the Uterus Anatomically the basket weave arrangement of the muscle fibers constituting the "active" upper segment (body) of the uterus differs widely from the arrangement of the fibers in the "passive" lower segment. In the latter there is a predominantly longitudinal arrangement. Late in pregnancy and more so during labor the thickness of this longitudinal layer becomes considerably attenuated. During the most normal labor the passive lower segment "thins out." During relative or genuine dystocia (difficult labor) or during obstructed labor the normal thinning of the lower segment becomes enhanced to a considerable and sometimes dangerous degree. The attenuation of this section of the uterus in such cases may proceed to the point of rupture. Its occurrence may be the result of the improper employment of oxytocics of any untimely manual or improper instrumental attempts at delivery or of extensions upward of lacerations originating at a lower level (vaginal vault or cervix) The latter accident is made even more likely in the presence of placenta previa Ruptures of this type are termed secondary or traumatic

Rupture of the uterine body is less frequent. It appears to be a consequence of defective musculature or of previous operation (scar) involving the myometrium, or of weakening of the wall as a result of myometrial disease. Such ruptures of the upper segment usually take place without warning early in or before labor These are referred to as spontaneous ruptures

Traumatic uterine rupture may be "complete," tearing completely through the uterus and its peritoneal covering, with profuse intra-abdominal hemorrhage and shock. If the laceration is "incomplete" it stops short of the peritoneum leaving that covering intact, while the resultant bleeding and hematoma are located in the folds of the broad ligament The condition in any case of rupture invariably constitutes an acute abdominal emergency

Each year certain obstetric deaths are attributed to uterine atony and hemorrhage. Careful and detailed review of these case histories, however leads to the speculation that some of these tragedies may have resulted from undiagnosed traumatic uterine rupture

Confronted after a difficult labor or delivery by a postpartum uterus which is guilty of persistent bleeding and/or atony the timorous obstetric surgeon hesitates to manually explore the birth canal. It is an attitude of hesitancy and indecision. A noteworthy obstetrical axiom is that after delivery of any case if there is persistent hemorrhage and uterine atony of obscure origin the patient should at once be the recipient of liberal blood transfusion and the subject of immediate visual and manual examination of the entire birth canal! This involves inspection of the perineum, vagina and cervix, and manual exploration of the upper and lower segments of the uterus!

Experience dictates the wisdom and necessity of this measure Hopefully *to* substitute oxytocics and a uterine pack for neglect to confirm or disprove the existence of a break or disruption in the integrity of the uterine wall is a grave mistake. In some instances failure

to observe this axiom results in the loss of a life which in more resolute hands might have been salvaged.

Postpartum hemorrhage and death due to this unfortunate accident is probably of more frequent occurrence than is reported The recognition of the casualty of rupture depends upon an intrauterine examination in every suspected case Immediate laparotomy followed by hysterectomy if necessary (rarely a clean linear rupture may be sutured) is the only rational treatment. Oxytocics here are useless The uterine pack has nothing to recommend it for this accident, unless it is employed only during the brief interval between diagnosis and operation Otherwise, it merely arouses spurious and futile hope and invites self-deception and procrastination by concealing the external bleeding from view Delay in diagnosis invites maternal death from internal hemorrhage, shock and peritonitis (see Table 10)

POSTPARTUM HEMORRHAGE

Following delivery even in the most normal case there is observed a blood loss generally not exceeding 200 cc Uncomplicated bleeding up to 300 cc is not rare and often may be termed physiologic Any amount in excess of this loss must be considered pathologic and regarded as postpartum hemorrhage. Hemorrhage begets shock and plays the leading role in all obstetric tragedies. In one of our series of 10 000 consecutive cases (Table 10) there were eight maternal deaths, of which three were due to hemorrhage

One of the objects of proper antenatal supervision and delivery is prophylaxis against those preventable circumstances which contribute to excessive bleeding Among the various precautions to which every woman in labor is entitled should be a record of her blood type and Rh status, and an adequate blood bank within reasonable access. Every parturient is a potential recipient of blood by transfusion (see Tables 5 and 10) One in every fifty will require it.

Unduly profuse hemorrhage may occur in the third stage or placental phase of labor If the placenta only partially separates the still attached portion prevents its complete expulsion from the uterus. Bleeding is inevitable. If manual massage and compression of the fundus (modified Crede method) performed with art and without undue force, is unsuccessful in effecting delivery of the placenta its early manual removal is indicated before the amount of blood loss becomes serious All surgical precautions concerning the field should be quickly observed The operator should exchange his gloves for a fresh sterile pair Long gloves are preferable

The internal hand with fingers together in the shape of a cone, is inserted into the uterus. The free external hand should rest upon and steady the fundus from above through the sterile drapes The tips of the fingers of the internal hand follow the cord to the placenta and seek the already separated area of the placental margin With the palm directed inward they are insinuated at this point into the line of cleavage between the placenta and the uterine wall With a gentle thrusting and sweeping motion of the fingers accompanied by pressure upon the fundus by the external hand, the entire placenta is freed in the plane of cleavage from its decidual attachment. It is important that the fingers remain in the plane of cleavage and that the dorsum of the hand remains adjacent to the uterine wall

TABLE 10

MAJOR CAUSES AND TREATMENT OF OBSTETRIC HEMORRHAGE (EXCLUDING ABORTIONS)

An Analysis of 10,000 Consecutive Pregnancies *

Cause	Number of Cases	Amount and Type of Bleeding	Abdominal Section	Vaginal Delivery	Curettage	Uterine Pack	Maternal Deaths	Cause of Maternal Death
Ectopic Pregnancy	32	Slight external 27 with internal	32	0	4 (Before laparotomy)	0	0	
Abruptio Placentae 1 Terminal or Minimal	33	300 cc. or less External	0	33	0	0	0	
2. Moderate	35	300 to 500 cc. External	0	35	0	0	0	
Severe	40	Over 500 cc. 11 External and concealed 29 External	9	31	0	1	0	
Placenta Previa 1 Marginal or Partial	54	200 to 500 cc. External	10	44	0	5	0	
2. Complete	14	300 to 1500 cc. External	13	1	0	1	1	Rupture of uterus (See below)
Postpartum Hemorrhage 1 Early	97	Over 500 cc. External	0	97	0	19	1	Subperitoneal hematoma
2. Late	42	Variable but persistent	0	42	14	11	0	
Uterine Rupture	5	1 None 4 Internal	3	2	0	1	2	1 following forceps 1 following version and extraction
Uterine Inversion	2	300 to 500 cc.	1	2	0	2	0	
Hydatidiform Mole	5	100 to 500 cc.	0	5	3	2	0	
Placenta Accreta	1	Slight (Attempted removal)	1	1	0	0	0	

From the General Hospital Obstetrical Unit, Department of Obstetrics, State University of New York, Syr[illegible]

When the maneuver is completed the bulk of the separated organ lies with its intact maternal surface against the palmar aspect of the internal hand.

During the procedure 1 cc. of pituitary extract is injected subcutaneously accompanied by uterine massage with the external hand This aids in maintaining uterine muscle tone The fingers of the internal hand should ascertain the integrity of the uterine wall as the placenta and hand are *expelled* not forcibly pulled from the uterine cavity

Intravenous or intramuscular methergine or ergotrate (1 cc or 0.2 mg.) should now be administered External fingertip massage, to insure firm contraction of the empty uterus, should be maintained for at least one hour or until uterine relaxation is unlikely Blood transfusion meanwhile should be continued to replace that lost by hemorrhage

Early postpartum hemorrhage denotes that which occurs within the first twenty-four hours after delivery Usually it is characterized by an immediate onset, but often due to failure to observe the tonicity of the uterus for a reasonable period (neglect) it is not discovered until later Aside from inattention to the uterus, during the period immediately following delivery its chief etiologic factors are

1 Atony (intrinsic) of the uterine muscle itself
2 Visible trauma (lacerations) of the birth canal
3 Invisible trauma of the birth canal
4 Retention *in utero* of portions of the placenta (The membranes seldom interfere with contraction of the otherwise empty uterus and hence rarely give rise to early hemorrhage The bleeding is from the placental site Retained membranes may cause subinvolution and invite later bleeding)

Atony of the uterus invites hemorrhage through failure of the muscle to sufficiently close or compress the open sinuses of the placental site The lack of normal tone may be intrinsic in the uterus itself or it may be a result of the effects produced by the anesthetic agent employed during delivery Deep anesthesia, sometimes required to produce adequate uterine relaxation for the performance of some obstetrical procedures, may result in sufficient residual relaxation to permit early postpartum hemorrhage

The active treatment of early postpartum hemorrhage includes

1 Measures to insure the operator that the uterus is empty and intact.

2. Prompt blood transfusion to combat its sequelae.

3 The administration of powerful oxytocics (ergotrate or methergine 1 cc., or 0.2 mg., intramuscularly or intravenously or pitocin 1 cc in 500 cc of saline or five per cent glucose by continuous intravenous drip twenty to forty drops per minute)

The atonic bleeding uterus should bimanually be elevated out of the pelvis, anteflexed, massaged and compressed between the closed fist against the cervix in the vagina and the external free hand One should always make certain the uterus is empty (retained placental tissue) and intact (rupture) and that the bleeding is not due to trauma (laceration) elsewhere in the birth canal (see under Rupture of the Uterus)

Transfusion and bimanual compression of the well flexed uterus with continued massage of the fundus is becoming increasingly popular in America in the treatment of postpartum hemorrhage

rhage The attitude of many American obstetricians, in deference to the observations of various British authorities is that removal of the uterus or its bimanual compression are the two alternatives in the control of the emergency of atonic uterine hemorrhage The loss of blood originates from the open sinuses of the relaxed placental site. The maneuver of bimanual compression aims at stimulation of the uterus to contract. It directly reduces the amount of bleeding by constricting these sinuses through combined internal and external pressure It possesses the real advantage of bimanual control of the size of the whole uterus for a short time. To maintain the effects of this procedure depends upon the duration of the anesthetic and the resistance of the operator against fatigue

The use of the sterile intrauterine gauze pack as a means of firm tamponade of the bleeding placental site seems now to be less often employed than formerly In ninety-seven cases of markedly severe postpartum (early) hemorrhage in our series packing of the uterus was employed nineteen times (Table 10) Actually the results observed with the gauze pack, properly and firmly compacted into the uterus, accompanied by external massage of the fundus, are often gratifying. External massage of the uterus after the pack is inserted may be maintained for hours or as long as necessary to insure a steadfast, unrelaxed state of uterine contraction. The intravenous drip of a pitocin infusion (1 cc. in five per cent glucose, 500 cc) aids in sustaining the uterine tone.

The efficacy of this treatment should not be deprecated. In contrast one could not likely for more than a short interval be able to maintain, with one fist and a part of the forearm in the vagina continuous pressure against the uterus and against the counterpressure of the external hand The argument that the firm gauze pack is unphysiologic and invites infection is quite plausible The same may be said of the bimanual procedure especially if the control of the bleeding demands its prolonged application. In practice however both methods have saved many lives and bleeding uteri, which might otherwise have been removed have subsequently borne children without incident.

Visible trauma, generally in the form of lacerations often is a source of blood loss following the second stage of labor The cut of episiotomy may at times involve a vessel (usually a vein) of considerable caliber Profuse and steady bleeding may result. It is a conservative measure to apply Allis clamps to all visible bleeding parts in the perineotomy wound, during and after delivery in order to effect hemostasis until repair can be accomplished. It is an exhibition of negligence to permit unchecked maternal blood to be wasted during the unpredictable number of minutes comprising the interval between the performance of episiotomy and the completion of the third stage of labor It is never too early to employ hemostasis

Inspection of the birth canal after delivery with repair of all lacerations, reflects the competence of the surgeon.

Invisible trauma along the birth canal may at times result in the formation of puerperal hematomas following delivery They represent the accumulation of blood (1) beneath the peritoneum (subperitoneal hematoma) (2) the vaginal mucosa (vaginal hematoma) or (3) under the skin of the perineum (vulvar hematoma)

The condition is by no means a rare

occurrence and may well be fatal (two cases in the author s experience died) It is due to hemorrhage from a damaged vessel, often without visible external evidence of laceration. It may follow spontaneous as well as operative delivery If the ruptured vessel lies above the pelvic brim the resultant subperitoneal hemorrhage dissects its way upward and may result in rapid death by maternal exsanguination Below the level of the pelvic brim, but above that of the superior pelvic (levator) fascia, the vaginal hematoma at first protrudes into the birth canal and obliterates its lumen as its size increases Below the level of the fascia of the pelvic diaphragm hemorrhage creates a readily discernible swelling The overlying skin appears smooth, edematous, and glistening, and shortly assumes an ecchymotic hue This is the characteristic appearance of a vulvar hematoma Fortunately the latter two types are the commonest.

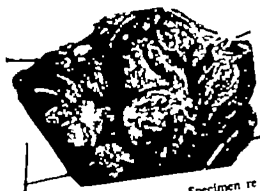


FIG. 14 Placenta accreta. Specimen removed by hysterectomy

Treatment of persistent bleeding due to subperitoneal hemorrhage necessitates laparotomy and direct control of the bleeding area The diagnosis is not usually immediately apparent and depends upon the recognition of all the signs of internal bleeding in the absence of any evidence of blood loss elsewhere. The signs correspond somewhat to those of a ruptured uterus, manual exploration of which confirms the absence of the latter accident It carries a high mortality

The other two types of hematomas may be anatomically restricted in size and result in spontaneous absorption. This event, however is not to be anticipated once the existence of its increasing size is recognized. Treatment in these cases consists of wide incision of the vaginal hematoma through the mucosa, and of the vulvar type through the skin The object is to evacuate the blood and blood clots A small cavity may be obliterated by suturing It is a mistake to pack the evacuated cavity or to explore it for the bleeding points if they are not at once apparent. Effectively to pack a large cavity invites more blunt dissection and separation of tissue during the packing process. This invites additional bleeding Firm packing of the vagina compresses and obliterates the cavity After a retention catheter is placed in the bladder perineal counter pressure against the vaginal pack is maintained by a pad and a T binder The pack should be removed after twenty-four hours Hemorrhage in these cases is usually venous in origin and its recurrence following removal of the tampon is rare

Retention of placental tissue is a common cause of hemorrhage postpartum The bleeding may be manifest early or late. After every delivery the placenta particularly one which does not spontaneously and readily separate from the uterus should be carefully scrutinized for its completeness. The same is true of the membranes Accessory placentae and succenturiate lobes inconspicuously remaining *in utero* following any de-

livery give rise sooner or later to most conspicuous evidence (hemorrhage) of their presence Any doubt calls for manual investigation to make certain the uterus is empty

Late postpartum hemorrhage denotes abnormal puerperal bleeding which occurs any time between the first twenty four hours after delivery and the interval of six weeks thereafter It is usually intermittent, painless, and moderate or profuse in amount.

The onset of late postpartum hemorrhage may be the first evidence of the presence of chorioepithelioma, but this is rare Most commonly some retained placental tissue is the offending cause Less often it appears to be due to local subinvolution of the placental site In any case it is important to ascertain the etiology Cautious exploration of the uterine cavity with the placental forceps or with the finger will in most cases reveal the presence of retained products. Careful but thorough scraping of the entire uterine cavity is sometimes necessary If the bleeding is due to subinvolution of the placental site the procedure will reveal no evidence of placental tissue.

One must always be prepared for liberal additional hemorrhage Blood transfusion, the antibiotics, the oxytocics, and in "clean" cases the uterine pack, should be available in anticipation of this possibility

ADDENDUM

Hemorrhage in any case must be viewed as a pathologic process and an indication for treatment. The diagnosis of the underlying factors responsible for the symptom will ordinarily direct attension to a rational method for its treatment. Research, time, and experience often lead to modifications of some systems of treatment, and sometimes lead to entirely new methods in our dealings with disease

The various axioms or principles of treatment represented in the foregoing pages coincide somewhat closely with those developed and at the present time generally observed throughout the obstetrical divisions of the Medical Center of the State University of New York at Syracuse. These principles in general represent the aggregate experience of an active teaching department, in the meticulous supervision of many thousands of women patients They likewise represent the methods currently included in the clinical instruction of nurses, medical students, internes, and residents

For painstaking review of the case records of nearly 25 000 consecutive pregnancies admitted between January 1 1946 and July 1 1952, the author is indebted to Dr *Bina Sawyer and Dr* Robert Maher of the resident house staff and to Miss Mary Walley Record Librarian, and her staff of assistants

For the excellent illustrations of the text the services of Miss Joanne Ashley young medical artist, are cheerfully acknowledged

To my colleagues, who are also my loyal and cooperative associates, from whose rich experience and clinical case records much valuable teaching material has been freely extracted, to be included in the preparation of these pages, I acknowledge with pleasure my indebtedness

BERNARD J FICARRA, M.D

35

Acute Gastrointestinal Complications Following Gynecologic Procedures

THE general surgeon and the gastroenterologist are often summoned to examine postoperative patients because of certain complications Gastrointestinal distress following pelvic surgery often demands consultations by both the surgeon and gastroenterologist. Usually the complication is successfully treated by conservative measures, occasionally the postoperative distress is a serious one In this situation active surgical intervention may be a necessity

Gynecological procedures, especially hysterectomy and oöphorectomy may result in the following postoperative complications

1 Acute gastric dilatation.
2. Adynamic ileus
3 Intestinal obstruction

Acute Gastric Dilatation This pathological condition is an acute enlargement of the stomach associated with vomiting dehydration, and sometimes a shock like clinical picture Gastric dilatation may occur within twenty four to forty-eight hours after operation The first symptom is usually vomiting. The vomitus is dark brownish green liquid having an offensive odor

As the process advances the vomitus becomes black in color This results from mucosal hemorrhage Distention is another early sign. Distention plus vomiting usually alarms the gynecologist and he requests consultation because he fears the patient has an obstruction. Gastric suction relieves the distention. The returns by suction are very gaseous suggesting that the patient has swallowed much air Dehydration and demineralization are overcome by intravenous fluids and chlorides. Prognosis is good when proper treatment is instituted as soon as possible. Surgical intervention is contraindicated. If the stomach distention goes untreated, a cardiac complication may result. It has been stated that overdistention of the stomach of an animal will arrest the heart [1]

Adynamic Ileus A temporary cessation of intestinal peristalsis occurs after every operation However the preference for pentothal anesthesia by many gynecologists increases the duration of this temporary paresis This problem has been called anoxic inhibition of small bowel peristalsis [2] When the distention progresses it may be termed a paralytic obstruction It is often difficult to differentiate an adynamic ileus from an early intestinal obstruction

In this type of case it is important to differentiate it from true obstruction and early peritonitis In general peritonitis the temperature is elevated and abdominal tenderness is marked.

Active treatment for adynamic ileus is proper intubation and suction. Maintenance of nutrition by the intravenous route is a supplementary necessary regimen Adequate blood studies to determine the type of alimentation are necessary The use of oxygen is a valuable adjuvant in adynamic ileus Enemata, Harris drip local abdominal heat, drugs such as prostigmine and spinal anesthesia are other aids in relieving this disturbing complication.

This condition may last for several days. If the complication is a true ileus it will respond to the conservative measures described.

Intestinal Obstruction The most serious complication following pelvic surgery is small bowel obstruction Early ambulation and vaginal hysterectomy have increased the frequency of this complication In both instances however the fundamental cause for small bowel obstruction is the attachment of a segment of small intestine to a nonperitonealized surface or the formation of an adhesive band on a "raw" surface

Early ambulation permits the small intestine to remain in the pelvic area since this is the most dependent portion. The inhibited peristalsis allows the nonactive intestine to become adherent to "raw" surfaces. In vaginal hysterectomy a satisfactory peritonealization is often impossible even in the hands of the expert gynecologist.

Small bowel obstruction following pelvic operations most frequently occurs within the first four postoperative days In order to prevent an obstruction it is well to institute a course of prostigmine for at least forty-eight hours following operation. The eating of a regular diet as soon as possible is another prophylactic measure against the development of an obstruction.

For the control of intestinal distention in small bowel obstruction an indwelling tube is passed immediately Successful management of the small bowel obstruction resides in the knowledge that this is a serious complication, and that strangulation of an intestinal loop may mean death In the early stages of an obstruction (within twenty-four hours of the onset) surgical relief of the obstructing mechanism will cause an almost immediate beneficial response in the patient's general condition One of the most important therapeutic measures in obstruction is the replacement of fluids and electrolytes

SUMMARY AND CONCLUSIONS

1 Attention is called to three gastrointestinal complications following pelvic operations

2 The first two, gastric dilatation and adynamic ileus are readily controlled by conservative measures

3 The third, intestinal obstruction, is most serious often necessitating surgical release of the obstruction and in cases where the diagnosis is delayed death may result.

4 Awareness of the possible occurrence of these complications will assist in arriving at an early diagnosis.

5 Early diagnosis, especially of obstruction will result in early treatment. Proper immediate treatment is the greatest safeguard against a mortality in small bowel obstruction following pelvic surgery

6 A detailed description of these complications with a discussion of their treatment may be found under their own title in the pages of this book

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SECTION V

MANAGEMENT OF ACUTE CONDITIONS OF THE OSSEOUS AND NEUROMUSCULAR SYSTEMS

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36

Emergency Treatment of Fractures of the Arm and Leg

Introduction It has recently been stated, jokingly but with a serious under tone, that with the rapid strides in pre ventive medicine and surgery soon the only doctors left would be obstetricians and fracture surgeons. Certainly the number of accidents on our highways and in our homes and factories on our farms and in our playgrounds are not diminishing in spite of the efforts of Safety Councils and Accident Prevention Boards With the increasing number of cars on the roads, traffic accidents are becoming an everyday occurrence, and the need for the knowledge of the emergency care of the injured becomes increasingly important.

Principles of Emergency Treat ment. The basic principle underlying all emergency treatment is very simple It is to prevent further damage to the individual and to the injured extremity The effects of the primary trauma cannot be prevented, but secondary trauma can be minimized or eliminated with prompt, efficient treatment. All too of ten the patient is moved unwisely, is urged to try to stand, and the closed fracture is converted into an open one with the resultant contamination and increased severity of the injury

The common sense of the well known admonition, "Splint em where they lie" is readily recognized when a little thought is given to the pathology of a broken bone Unfortunately it is not an isolated phenomenon like a cracked table leg A bone is surrounded by soft tissues, periosteum, muscles, nerves, blood vessels, and skin. It cannot be broken without some injury to these adjacent soft tissues In some cases, as in the slight buckling of a child s radius, that injury may be microscopic in others there may be extensive tearing of muscles, nerves, blood vessels, and even skin. The injury to the bone itself may be of the least importance as far as the ultimate rehabilitation of the patient is concerned. Therefore, immediate immobilization of the extremity prevents the jagged bone ends, if displaced, from tearing more soft tissue if undisplaced by the original trauma, from slipping out of position by injudicious handling

During the first fifteen or twenty minutes following a fracture there exists a state of local tissue shock, during which time the patient feels numbness but has little pain. The muscles are soft and the soft tissues unresisting This is, therefore, the optimum time to apply some

form of immobilization. During this period if a doctor happens to be at hand reductions can occasionally be done without anesthesia. As soon as *this period is passed, however, pain appears,* the muscles go into protective spasm and most attempts at reduction without anesthesia are not only futile but dangerous

Another important concomitant of immediate immobilization is the lessening of pain thereby diminishing the patient's shock Consideration for the individual who is attached to the broken extremity is of prime importance Any one who is injured in any kind of an accident is in shock to greater or lesser degree not only physically but mentally Careless handling of a broken arm or leg adds to that shock Treatment of both kinds of shock should be instituted as soon as possible It is surprising what a few words of reassurance combined with adequate immobilization of the injured limb will accomplish

Treatment at the Scene of the Accident In large metropolitan areas ambulances are so readily available that the medical passer-by rarely if ever is called upon for help If he should be so involved his main job is to prevent injudicious moving of the patient until the ambulance with its supply of splints arrives Even if traffic is being halted and the police impatient it is unwise to carry a seriously injured patient from the street to sidewalk or store until the injured extremity is splinted. One move from street to stretcher is enough. Soft hearted bystanders may think you brutal to leave the poor man lying in the road but far better that than to see a broken leg dangling from the arms of the eager helpers. It takes courage to do nothing until the proper equipment arrives, but it may save the life or limb of the patient. As the late Dr Darrach used to say "If you can't help don't hinder"

In the country the situation is different. Ambulances are not so quickly available, and a doctor must stop to help Frequently, the local doctor is called to the scene before the ambulance Means of immobilization may have to be improvised, for few doctors, unfortunately carry Thomas splints in their cars. Fence rails skis boards, or failing anything else the other leg may be used Ingenuity will solve the problem if the fundamental principle is remembered. It doesn't matter what you use but use it adequately In other words don't use a two-foot board for an obviously fractured femur That is not immobilization it is a gesture

Shock can be combatted at the scene of the accident by warmth, coats blankets, etc., and by relieving pain with adequate sedation if it is at hand Morphine is contraindicated, of course in suspected head and abdominal injuries, as it masks the diagnostic signs Obvious wounds should be covered with sterile dressings if available Clean towels or handkerchiefs will protect them from gross contamination and will supply the pressure useful to control bleeding Tourniquets are rarely needed and should be used only for major arterial damage. If a tourniquet is used the time of application should be noted, and a piece of paper pinned to the patient's shirt should state the fact In the confusion of a major accident the fact that a tourniquet has been applied may escape the notice of other doctors and not be discovered until severe damage has been done to the circulation of the extremity

Transportation of an injured patient to a hospital is of great importance If an ambulance is not available The floor

of a truck or a station wagon is the most satisfactory substitute the rear seat of the modern sedan the least so unless some way can be devised to allow the patient to lie out straight. It is also entirely unnecessary to drive to the hospital at seventy miles an hour causing more pain and shock at every bump on the road.

Not many years ago there was a head-on collision in one of the highways A man of fifty-six was thrown to the road and sustained a closed but obvious fracture of the right femur He was conscious The nearest hospital was fifteen miles away and the police phoned for the ambulance to be sent out, but the kindly but impatient bystanders would not wait. They bundled the man into the back seat of a sedan, doubled him up on the seat for he was tall, and the driver with his hand on the horn and his foot on the accelerator dashed to the hospital. When they reached the emergency room the broken end of bone was sticking through the trouser leg

The scene of the accident is not always a road or highway and frequently the doctor is summoned to the house to care for a patient who has fallen from a stepladder down the cellar stairs or has slipped on a scatter rug Here the means of immobilization are more easily obtained For fractures of the wrist or forearm a magazine bandaged around the padded extremity is quite efficient. Slings and bandages for arm and shoulder injuries can be formed from old sheets A bed pillow bandaged firmly around a broken ankle is a comfortable support.

The Thomas splint is still the best form of immobilization for fractures from the hip to the ankle and should be part of the equipment of every ambulance and emergency room It not only supplies support to the injured leg but provides traction to combat muscle spasm and prevent or minimize overriding of the bone ends The application of a Thomas splint is simple The ring or half ring must fit against the ischial tuberosity to provide the point of countertraction. The pulling force is provided by a sling or tie around ankle and foot with the shoe left on and pulled tight to the end of the splint. The amount of pull is increased by winding up the rope or bandage with a stick, the so-called Spanish windlass The leg is then bandaged into the splint by a continuous heavy bandage or by slings around extremity and splint above and below the knee. The splint should then be supported by bricks, books, or blocks at its most distal point so that the heel hangs free and does not rest on stretcher or floor Otherwise, the pull is lost. Most Thomas splints come equipped with canvas slings ankle straps and metal supports but these are not necessary A simple loop tie around ankle and foot is adequate Whatever is used, care must be taken not to compromise the circulation of the foot. Therefore, circular bands of adhesive plaster around the ankle are dangerous and should not be used. Ambulance drivers, Boy Scouts, firemen, and policemen usually know how to apply one of these splints and it would be well if all doctors did.

Badly displaced elbows frequently present a problem. If the extremity is extended a simple board splint or its equivalent from shoulder to fingers is easy But if the elbow is flexed, no attempt should be made to straighten it until the time for definitive treatment is reached. *It should be immobilized in the position in which it is found.* This can be done by means of two splints

one medial and one lateral extending across the joint from arm to forearm and bandaged in such a way as not to cross the joint and interfere with the circulation. In all elbow injuries the presence or absence of the radial pulse should be noted by the first doctor who sees the patient. The absence of a radial pulse indicates a threat to the circula tion of the forearm and hand and means that rapid action must be taken and definitive treatment instituted with the least possible delay

A word of warning should be inserted here before leaving the subject of injuries in the home. Every woman over fifty years of age who has had a fall and complains of pain and discomfort in or around the hip should be consid ered *to have a fracture of the hip until* it is definitely proved otherwise. There may be no deformity no shortening, nor external rotation of the extremity but there may be an undisplaced frac ture which can slip if not recognized. Adequate x rays must be obtained in spite of patient or family protest.

Treatment in the Office· If the patient is first seen in the doctor s office the chances are great that the injury is to the upper extremity A rapid but careful examination will reveal deformity tenderness circulatory or nerve damage and adequate immobilization can then be carried out before x rays are obtained At this point the need for immediate x rays must be stressed All too frequently a wrist that shows no deformity is diagnosed as a sprain and, because x rays were not considered nec essary a fracture of the navicular is missed Many doctors working in small communities have x ray equipment in their offices Others have hospital x ray departments within a reasonable dis tance If for some good reason an immediate roentgenogram cannot be obtained, a reduction of a dislocated shoulder by simple traction or a Colles fracture under local anesthesia might justifiably be attempted in the doctor s office providing that x-rays are obtained at the earliest possible opportunity This is for the protection not only of the patient but also of the doctor Prereduc tion x-rays however should be taken wherever possible

If the patient is to be sent out of the office to be x-rayed the injured extremity must be immobilized. Patients can slip going down the steps of the office or on an icy sidewalk and must be protected *from further injury*

Treatment in the Hospital: Some patients present themselves first in the *emergency rooms of a hospital or are* brought in by family or friends. Just because they are within the walls of a *hospital there should be no deviation* from the fundamental principle of immediate immobilization Unfortunately *the injured extremity is not immune* from further damage just because the patient is supposedly under the expert care of hospital attendants. Emergency splints should be applied as soon as the patient enters the door and accident ward nurses and orderlies should be instructed in their application Hospital floors are likely to be slippery x-ray technicians may be too eager to get accurate positions patients may inadvertently roll off examining tables Im mediate adequate immobilization *is* essential

After the patient has reached the hospital by ambulance, truck doctor s car or on foot, and the immobilization checked or applied, a careful but rapid examination should be made to rule out any other injuries Occasionally a dislocation of a hip may be missed because

the fracture of the shaft of the femur is so obvious Unfortunately there is no rule restricting an individual to one fracture only and especially in automobile accidents the injuries may be multiple Means to combat shock should be started immediately with intravenous fluids at once and whole blood as soon as possible Again, it is essential not to disturb or move the patient unnecessarily Portable x-rays can be taken in the emergency room if there is a machine available If not, with a little ingenuity on the part of the technician x rays can be taken without moving the patient from the stretcher When the examination is completed the x rays available, and the necessary laboratory data at hand definitive treatment can be undertaken. The time to reduce a fracture is as soon as possible. The longer the time has elapsed between injury and reduction the harder it is to get anatomical reposition of the fragments Blood clots and becomes organized, the soft tissues become edematous, and muscles lose their elasticity The process of repair which Nature sets up immediately after injury becomes disrupted by the forcible maneuvers needed for the replacement of the bone

Treatment of Open Fractures. Open fractures are those which have a wound in the skin communicating with the fracture In these cases the problem of contamination is added to the problem of bone and soft tissue damage. The wound should be covered with sterile dressings with pressure bandages if necessary to control bleeding No attempt should be made to clean the wound, and no antiseptics should be used until the patient is in the operating room. Once applied, the initial dressing should be left untouched until definitive treatment is initiated. Once the wound is covered, immobilization of the extremity should be carried out as has been described. If bone is projecting through the skin it is probably wiser not to use traction, as further contamination will follow the pulling in of dirty bone and soft tissue

Tetanus antitoxin should be given to all patients with open fractures, of course after skin tests for sensitivity unless they have been previously immunized with tetanus toxoid In the latter cases a booster dose of toxoid should be administered Prophylactic penicillin can be given in the accident ward but it should always be borne in mind that antibiotics are no substitute for careful surgery Time is a most important factor in all open fractures for the longer the wound remains contaminated the more likely it is to become infected Open fractures are therefore emergencies of a high priority and everything should be planned to expedite them to the operating room It is sometimes difficult to persuade hospital authorities that it is not necessary to undress these patients completely put them into bed, and then take them out of bed again to go to the operating room properly dressed in cap and leggings Those garments that can be removed without disturbing the patient or removing the splints may be taken off in the accident ward The patient should then go directly to the operating room, examination, x-rays, and laboratory tests having been completed and the rest of his clothing removed after he is anesthetized. Then and only then should the immobilization and dressings be removed. With the wound protected with sterile gauze, the extremity should be shaved and carefully washed, not by the orderly but by the operating surgeon before he scrubs up The area can

then be prepared with the usual technic employed in the particular hospital The patient is draped the surgeon gowned and gloved and the operation is ready to be started. Careful debridement of these wounds implies the removal of all dead and dying tissue all gross contamination and foreign material, and the conversion of the wound into one that is as surgically clean as possible Irrigation with saline or sterile water to wash out contamination and flush the wound is an essential part of the procedure Antiseptics should *not* be used. When the wound has been rendered as surgically clean as lies in the surgeon's power the fracture can then be treated by whatever method he thinks advisable in the particular case.

Two admonitions should be reiterated in the treatment of open fractures —speed between injury and operating room is essential, and antibiotics are no substitute for surgery

Suggested Methods for Emergency Immobilization. FOR INJURIES OF SHOULDER AND ARM A sling under the wrist with a swathe holding the arm to the chest is usually adequate The weight of the forearm if the elbow is unsupported gives some traction to the arm. The Murray Blake hinged arm splint is hard to apply safely and has largely been discarded

FOR INJURIES OF THE ELBOW Medial and lateral splints of wood, or cardboard or with gross deformities a pillow splint will hold the extremity relatively immobile until definitive treatment can be instituted

FOR INJURIES OF THE FOREARM AND WRIST Basswood splints shingles, magazines can easily be bandaged to the injured extremity to keep it from further damage

FOR INJURIES OF THE HAND AND FINGERS Any method that will hold the hand in the position of grasp is good. A tennis ball, an inverted cup or a large roll of bandage held in the palm with the hand and fingers bandaged around it holds the fractures well and may correct displacement.

FOR INJURIES OF THE HIP AND THIGH The best method of splinting is by the Thomas splint. Failing this any long board extending from axilla to toes will do or if nothing else is available the use of the other leg is better than nothing.

FOR INJURIES OF THE KNEE Medial and lateral board splints or a pillow splint work well if the knee is in the flexed position If the knee is extended a posterior splint of some kind can be devised.

FOR INJURIES OF THE LEG A Thomas splint is the most satisfactory means of immobilization for any fracture above the ankle Medial and lateral board splints can be used if they extend above the knee and below the foot

FOR INJURIES OF THE ANKLE Medial and lateral board splints can be used, but a pillow splint is most satisfactory in cases with gross deformity

FOR INJURIES OF THE FOOT Pillow splints are probably the most satisfactory for the severely injured foot. Because of the swelling associated with these injuries elevation of the extremity is of utmost importance

ANTHONY F DEPALMA M D AND HAL E SNEDDEN, M.D

37

Acute Nonfracture Injuries of the Shoulder

RUPTURES OF THE MUSCULOTENDINOUS CUFF

General Stability of the glenohumeral joint is not dependent upon the configuration of its bony components but upon the muscles which motorize it, primarily those comprising the musculotendinous cuff First should be recalled the anatomy of the musculotendinous cuff All four rotator tendons (supraspinatus, infraspinatus teres minor and subscapularis tendons) are welded together with the fibrous capsule into one musculotendinous sheath interlacing intimately with one another and with the fibers of the capsule so that it is impossible to separate, even with sharp dissection the components of the cuff at its point of insertion (Fig. 1)

Before any attempt is made to understand the pathology in this region one must first recognize the concept of function and motion in the glenohumeral joint. Motion is dependent upon groups of muscles working as a unit. This is the basis of a neuromuscular balance between the components of the cuff coordinating the overall performance Such is the case in the glenohumeral joint whereby the rotator muscles, working as a unit through the musculotendinous cuff, play an important role in abduction and elevation of the arm The cuff establishes a fulcrum for the humeral head in the glenoid cavity by holding the head firmly against the glenoid and at the same time, depressing the head. The pull of the deltoid muscle is directed and guided by the rotator muscles. The supraspinatus muscle although not initiating abduction, is an abductor of the humerus acting simultaneously with the deltoid Thus loss of function in this joint is in direct proportion to the impairment of muscle balance between the rotator and the deltoid muscles

Etiology The musculotendinous cuff is particularly susceptible to degenerative alterations because of the mechanical inadequacy of the shoulder joint to meet the requirements of the prehensile extremity Thus, when repeated traumata are added to the normally early and progressive degenerative changes in this region, rupture of the cuff is an inevitable sequel. Associated predisposing factors are (1) Senescence—this contributes to a high degree Clinically most tears occur after the fourth decennium unless there is a history of violent injury (2) Attrition—the supraspinatus area of the cuff is subjected to constant frictional trauma as it passes under the acromion and coracoacromial ligament

when the arm is abducted (3) Mechanical and anatomic factors—the cuff, acting as a fulcrum for the head of the humerus in the glenoid cavity is subjected to great additional forces in the divergent pull of the rotators which over a period of time weakens the cuff in the supraspinatus area and predisposes it to tearing. (4) Occupations—this lesion is most frequently encountered in patients engaged in laborious or athletic activity

It affects men ten times more often than women and more often the right shoulder than the left shoulder Among the active etiological factors is injury which most often is that of falling on the out stretched arm Occasionally the trauma may be lifting some object or elevating the arm suddenly although the latter applies more to the older age group Direct injury does not cause tearing of the cuff because it is protected by the overhanging acromion. In the first three decades, severe trauma is a prerequisite in the history in order to make a diagnosis of a cuff tear In the older groups

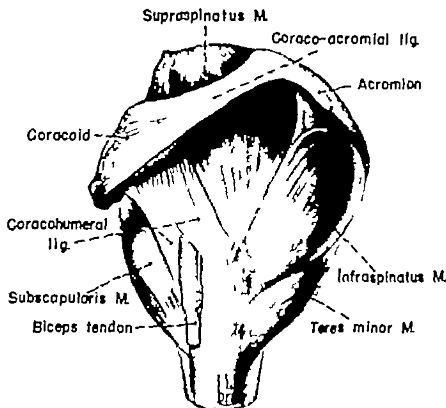


FIG. 1 Subdeltoid region of the left shoulder Observe the coracohumeral ligament extending from the outer border of the horizontal limb of the coracoid process to both tuberosities bridging the intertubercular sulcus, also the triangular coracoacromial ligament and the compactness of the rotator muscles which fuse with the fibrous capsule forming the musculotendinous cuff before they insert into the superior portion of the anatomic neck of the humerous. Note that the lower fibers of the subscapularis muscle anteriorly and the infraspinatus muscle and the teres minor posteriorly insert directly into the shaft of the humerus.

All illustrations in this chapter are from the senior author's book Surgery of the Shoulder and are reproduced through the courtesy of the publishers, J B Lippincott Company Philadelphia.

any history of injury or excessive strain or indirect force should lead one to suspect the presence of this lesion.

Classification and Pathogenesis· Ruptures of the musculotendinous cuff are divided into two categories (1) partial or incomplete tears which may involve either the synovial or bursal side of the cuff but which never involves the entire thickness of the cuff and (2) complete tears which implicate the entire thickness of the cuff in are torn from their bony insertion. The fibers often retract, forming a mobile tab which may give rise to symptoms of internal derangement of the joint. (2) Tears within the substance of the cuff without involvement of the synovial or bursal surfaces These cause the cuff to laminate into two or more layers (3) Tears on the bursal side of the cuff Such lesions reveal tearing of the superficial fibers just proximal to their point of insertion into the facet of the greater

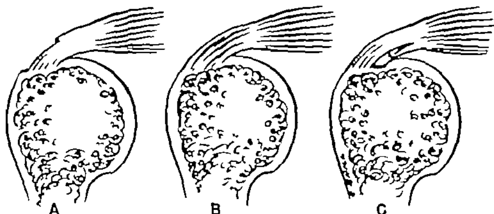


FIG. 2. Types of incomplete tears (A) on the bursal side of the cuff (B) within the substance of the cuff (these lesions are believed by some workers to be the forerunners of calcareous tendinitis) and (C) on the synovial side of the cuff, close to the insertion of the cuff into the head of the humerus.

these lesions a direct communication is present between the subacromial bursa and the joint cavity A complete tear may be almost imperceptible or may be a massive avulsion of the cuff. The supraspinatus region of the cuff is the most frequently involved particularly in complete tears the infraspinatus teres minor and subscapularis regions either alone or in combination, are involved in the above order of frequency

Incomplete tears in the supraspinatus region of the cuff are further subdivided into four types (Fig 2) (1) Tears on the synovial side of the cuff (rim rents) These lesions involve the deep tendon fibers which together with the synovialis tuberosity The floor of the subacromial bursa is involved in all of these lesions in that the floor becomes thickened, often forming numerous villi or thick synovial folds. (4) Tears running parallel with the cuff fibers These lesions are the least frequently encountered, but if found and involve the bursal floor they lead to the same bursal changes noted above.

Complete tears in the supraspinatus region of the cuff are also subdivided into four types (Fig 3) (1) Pure transverse ruptures. These lesions are infrequently encountered but when they do occur the transverse tearing occurs in the cuff slightly proximal to its fine

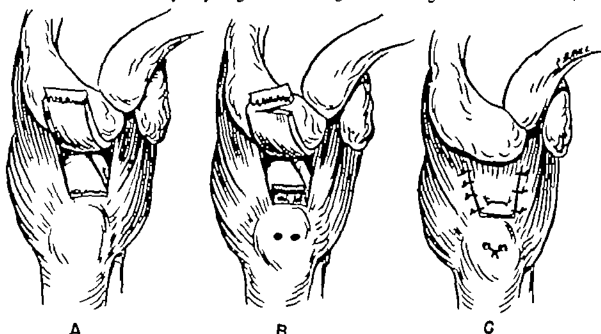


Fig. 3 McLaughlin's concept of the formation of cuff defects. (A) First a transverse tear or rupture of varying size occurs as the result of trauma inflicted on a degenerated cuff (B) Repeated traumata cause extension of the tear both in the transverse and longitudinal axis. (C) Divergent forces act on the longitudinal arm of the tear the subscapularis pulls the anterior edge of the tear forward and the external rotators pull the posterior edge backward, producing a triangular or crescentic effect.

of insertion into the tuberosity Retraction of the tear usually is very slight because the edges of the defect are continuous with the intact adjacent cuff These lesions frequently develop into triangular or crescentic lesions, particularly if superimposed upon a weakened and degenerated cuff (2) Pure vertical rents or longitudinal slits paralleling the direction of the cuff fibers These lesions occur invariably in young individuals who have sustained violent injuries to the shoulder joint Frequently associated with this type of lesion are fractures or dislocation of the humeral head In general, the rent runs parallel with the joint cavity through the fibers of the coracohumeral ligament which occupies the interval between the supraspinatus and the subscapularis muscles and which bridges the intertubercular sulcus This lesion may extend into the substance of the upper end of the humerus as far as the surgical neck. In these instances the greater tuberosity is fractured at its base and pulled upward and backward by the external rotators while the humeral head is displaced downward and forward by the pull of the subscapularis muscle Thus, the opposing forces of the external rotators and the internal rotator tend to separate the edges of a longitudinal rent thereby preventing healing and favoring extension of the tear These lesions invariably result from violent injury inflicted upon the strong and healthy musculotendinous cuff of the young individual capable of resisting transverse tears (3) Tears with retraction These are longitudinal tears which usually begin at the anterior end of a transverse tear Further trauma, minor or severe, tends to increase the extent of the lesion both in

the transverse and the longitudinal axis of the cuff fibers The longitudinal arm of the lesion is acted upon by the divergent forces of the external rotators and the internal rotators as in the longitudinal rent, thereby producing typical triangular or crescentic defects which are disclosed at operation. In old lesions of this type, the edges on the synovial side of the defect are smooth and hypertrophied (a reparative attempt) This often leads one to misinterpret the lesion as having only a transverse component whereas actually it is both transverse and longitudinal (4) Massive avulsion of the cuff Most often, all of the external rotators are involved and retracted in these lesions The longitudinal tear takes place through the coracohumeral ligament between the supraspinatus and the subscapularis muscles. Occasionally the subscapularis is involved. When the cuff retracts, it often hangs as a curtain between the humeral head and the glenoid cavity

Clinical Features. COMPLETE TEAR IN THE SUPRASPINATUS REGION OF THE CUFF In describing the clinical features of this lesion, one must keep in mind that they are governed by the type of trauma, duration of the lesion, severity and the extent of the secondary pathologic alterations that ensue in the subacromial bursa, the humeral head, the tuberosities, and the biceps tendon.

The pertinent clinical features of complete tears are (1) age, (2) occupation, (3) a history of injury (4) pain, (5) impaired function, and (6) the local clinical features The first three features have been previously mentioned.

Pain. Sudden, sharp pain at the time of the injury is a constant and characteristic feature The pain may be localized at the tip of the shoulder or may be referred to the insertion of the deltoid muscle The pain usually subsides within a few hours but recurs in six or twelve hours with greater intensity which increases progressively for five or seven days and then diminishes Often the patient experiences a snapping or tearing sensation in the shoulder at the initial onset of pain Hemorrhage causes a tension type of pain, thus, when the hemorrhage is absorbed the pain decreases

Impaired Function. This may be the result of abnormal mechanical factors or may be due to pain with associated muscle spasm It is often impossible to determine the severity of the lesion in the acute phase. Severe pain occurs in instances of minor cuff damage when the involved fibers impinge under the coracohumeral ligament or the acromion during abduction. This painful arc is between 80 and 110 or 120 degrees. If one eliminates the pain factor free full range motion can be attained. This can be accomplished by infiltration of this cuff with procaine or by manual depression of the humeral head by the examiner If either instance, impingement of the impaired cuff against the coracoacromial ligament is not felt, hence a free painless range of motion ensues The impairment of normal function is dependent upon the *extent of the* cuff tear and the secondary changes in the adjacent structures. Complete cuff tears, within certain limits, are compatible with normal and painless shoulder motion, dependent of course upon the extent of neuromuscular imbalance

Faulty scapulohumeral rhythm is a constant feature of complete tears of the cuff The ratio is 2 1 of scapulohumeral to scapulothoracic motion in a normal joint this ratio is constant throughout elevation.

Local Clinical Features. Character

istic of complete cuff tears are (1) tenderness this most often is over the tip of the greater tuberosity but may be frequently found either at the insertion of the deltoid muscle or directly over the site of the tear (2) Jog and soft crepitus a jog is a catch when the arm is abducted and the tear passes under the coracohumeral ligament Crepitus frequently may be palpated at this point of motion Neither of these are pathognomonic of a complete tear as they are frequently found in many conditions giving rise to internal derangements of the joint. (3) Atrophy of the rotator muscles this of course is dependent upon the duration and severity of the cuff tear Frequently hypertrophy of the deltoid muscle is seen due to the muscular imbalance caused by the lesion, thus masking cuff atrophy (4) Presence of fluid this is found in most cases of old complete tears and can be palpated in the subacromial bursa when the arm is elevated as high as possible (5) Eminence and sulcus when the arm is in dorsiflexion the sulcus, which is the site of the tear may be palpated just anterior to the edge of the acromion. The eminence is the normal prominence of the greater tuberosity

INCOMPLETE TEARS IN THE SUPRASPINATUS REGION OF THE CUFF The same set of criteria with a few exceptions is used to determine this type of lesion as is used for a complete tear They are (1) age (2) occupation, (3) history of injury (4) pain (5) local tenderness, and (6) atrophy of the rotator muscles Once again it must be remembered that the severity and duration of the lesion alters the physical findings Signs such as an eminence and sulcus are variable, as are jog and crepitus. There is never a collection of synovial fluid in the bursa. One feature which differentiates partial from complete tears is that in the former there is always good power of abduction and elevation, a function that is always impaired to some degree in a complete tear

Radiographic Findings in Ruptures of the Musculotendinous Cuff Unless there is involvement of the osseous elements of the shoulder joint, it is of no significance except when there is marked muscle spasm in the acute stages The humeral head may be found high in the glenoid cavity

Long standing cases may show some increased localized density in the tip of the greater tuberosity and at times some spurring in the region or exostoses may be formed on the tip of the greater tuberosity

Cases with massive and complete long standing avulsions of the cuff may reveal recession of the tuberosities and hypertrophic changes on the outer surface of the humeral shaft. Anteroposterior lateral, and oblique views are necessary to demonstrate these changes These studies are of little or no value except in complete tears

TREATMENT

Conservative Both incomplete and complete tears will be considered together here as the management is essentially the same during the early phases. This might be termed a five point program or regimen (1) Alleviation of pain, (2) overcoming muscle spasm (3) restoration of motion (4) prevention of muscular atrophy and (5) prevention of disturbing sequellae

The alleviation of pain and overcoming of muscle spasm usually run hand in hand. Sedatives and infiltration of the cuff with 5 cc of one per cent procaine often give dramatic relief When

the pain and muscle spasm are relieved the patient is able to start restoration of motion Rest is a salient feature best effected by placing the arm in a sling and at the same time instructing the patient to take the arm out of the sling for gravity free exercises to be executed for three to five minutes every two to three hours (Fig 4) Physical therapy in the form of radiant heat and gentle massage may be added to the program Normally the acute symptoms subside in four to five days, at which time the sling is discarded and wall

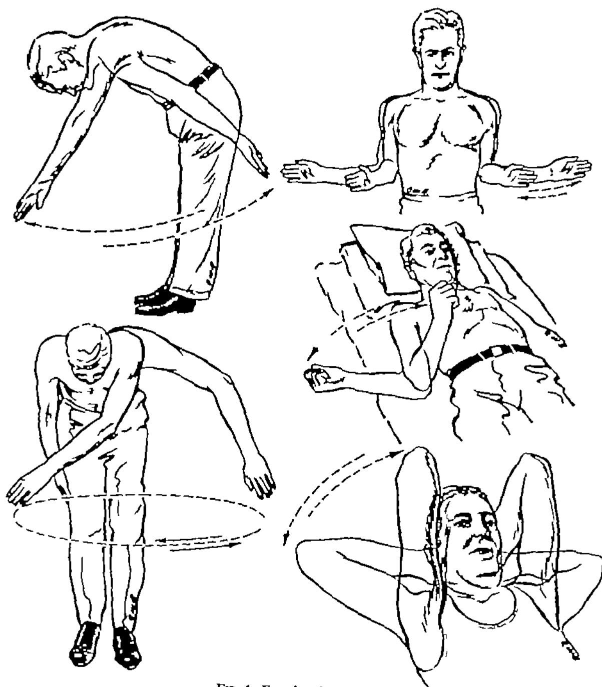


Fig. 4 Exercises for shoulder

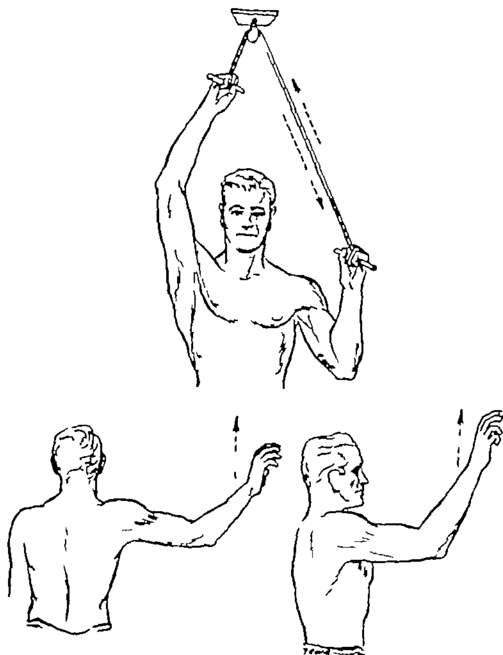


FIG. 4A. Exercises for shoulder (continued)

crawling exercises are started. These latter exercises are then gradually incorporated into normal arm motions In the regimen certain elements are to be avoided The patient is at all times to avoid motion beyond the tolerance of pain or fatigue to avoid any passive manipulation, and to avoid any period of total immobilization. It is of utmost importance that the surgeon have the complete cooperation of the patient for this regimen to be effective This plan of therapy is applied to both early and old lesions incomplete and complete. One can reasonably expect response to this type of therapy in a three to six

week period if it is to be successful One should allow ten to twelve weeks to elapse in incomplete tears before justifying surgical intervention In com plete tears, an interval of six to eight weeks is not too long a time to elaps before operative repair of the lesion contemplated

Before any operative procedure done one must evaluate the degree o

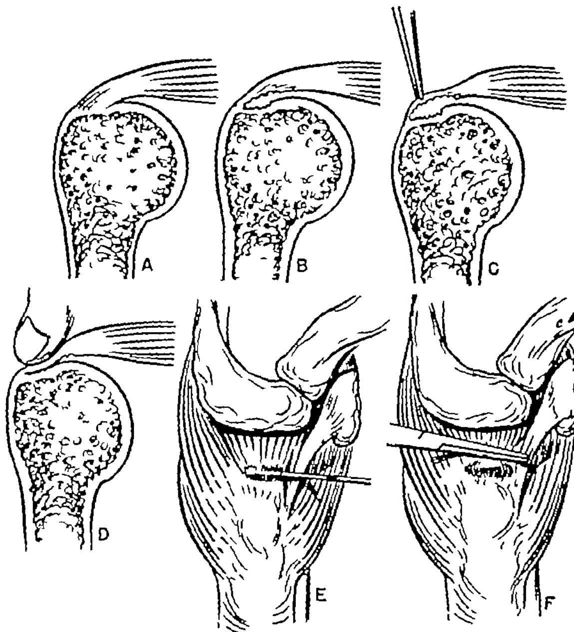


FIG. 5 Aids in arriving at a diagnosis of incomplete tears of the cuff. (A) Normal inser tion of the cuff into the humeral head, fibers are firmly attached and cannot be lifted off. (B) Rim rent or incomplete tear (C) Outer fibers of cuff in incomplete tears can be lifted from the head of the humerus. (D) Finger can palpate sulcus and irregularities on the humeral head through the thinned cuff. (E) Longitudinal split in cuff will permit probe to be inserted into the side of the cuff, also permitting visualization of the inner surface of the cuff. (F) Blister is raised when instrument is passed laterally over the cuff (Redrawn, with modifications, from McLaughlin)

impaired function and the patient's need for improved function

Surgical Treatment. INCOMPLETE TEARS The sole objective of surgery in *this type of lesion is to allay abnormal* friction between the coracoacromial arch and the musculotendinous cuff Fre-

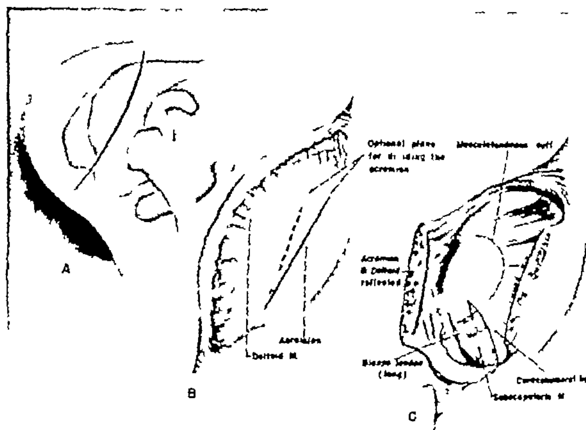


FIG. 6. Transacromial incision (McLaughlin) (A) Skin incision. (B) Planes through which acromion may be divided to gain access to the subacromial region. (C) Structures exposed after the deltoid is reflected downward and outward.

quently it is difficult to locate the le*sion in that the continuity of the cuff* is not disturbed. Lesions on the synovial side of the cuff (rim rents) may be palpated The cuff may be elevated by a hemostat revealing a partial loss of attachment. Longitudinal lesions and those on the bursal side are easily seen Those tears on neither the bursal nor synovial side frequently raise a "blister" at the site of the lesion when an instrument is passed laterally over the cuff (Fig. 5)

The repair of all four types of incomplete tears is very similar Of several different types of approaches, the Mc Laughlin or transacromial approach provides the most ideal exposure (Fig. 6) The skin incision begins at the posterior border of the acromion, just lateral to the acromioclavicular joint and is carried anteriorly to a point three to five centimeters (1½ to 2 inches) in front of the anterior border of the acromion The incision is developed anteriorly through the deltoid muscle the *bursal sac, which immediately overlies*

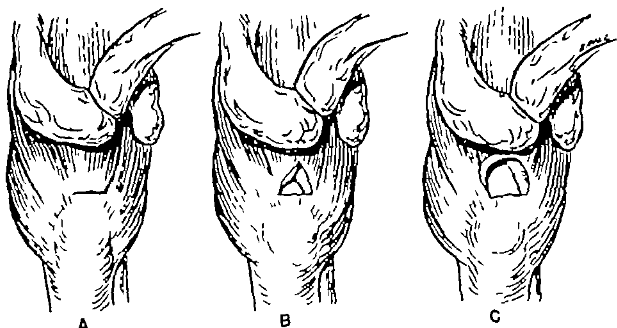


FIG. 7 Repair of incomplete ruptures of the supraspinatus region of the cuff. (A) A longitudinal incision is made parallel to the tendon fibers between the supraspinatus and the subscapularis tendons next, a transverse incision is made extending posteriorly The length equals the width of the rupture. A second longitudinal incision is made parallel to the first. (B) The affected portion of the cuff is excised. A bony trough is made in the ana tomic neck of the humerus. (C) The freshened end of the cuff is reattached by mattress sutures.

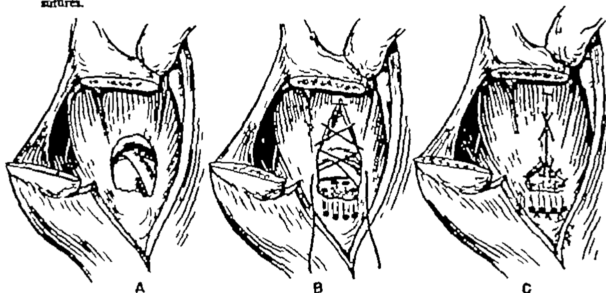


FIG. 8 Method of repair of complete ruptures (after McLaughlin) (A) Rupture in cuff exposed through a transacromial incision the degenerated margins of the defect are excised back into healthy tissue. (B) Shoelace type of continuous suture, beginning at the apex of the defect, is used to approximate the freshened edges of the cuff. (C) The edges are approximated up to the point of tension with the arm at the side· a triangular hiatus usually remains in the cuff. The articular cartilage of the head of the humerus just below the defect is removed, exposing raw bone The cuff is reattached to the humerus by passing the ends of the continuous suture through drill holes, tying them on the outer surface of the greater tuberosity· If necessary additional mattress sutures may be added to attain better approximation of the edges of the cuff to raw bone.

the cuff is then in view For better vision of the posterior and inferior portions of the cuff, the lateral tip of the acromion must be removed by osteotomy The removal of a portion of the acromion actually may be part of the surgical therapy in that it removes the point of painful impingement of the cuff on abduction of the arm

The type of repair of course, varies with the type of lesion encountered. Those lesions on the synovial side of *the cuff (rim rents) and the tears on* the bursal side of the cuff are repaired alike (Fig 7) A longitudinal incision is made through the fibers of the coracohumeral ligament This allows visualization of the rim rents on the synovial side A transverse incision is then made just proximal to the point of insertion through the entire depth of the cuff the length being equal to the width of *the tear Another longitudinal incision* is made paralleling the first, thus lifting a flap which includes the tear The torn portion is excised remodeling the end of the flap for reinsertion. A trough is made in the anatomic neck of the humerus and the flap anchored in this trough by means of mattress sutures extending through drill holes in the greater tuberosity The longitudinal limbs of the flap are then approximated to the adjacent cuff by means of interrupted sutures

Longitudinal tears or tears in the substance of the cuff are best treated by elliptical excision of the tear and reapproximation of the cuff with interrupted sutures In closing the wound the osteotomized portion of the acromion is removed and the coracoacromial ligament *is divided close to its insertion into the* medial edge of the acromion thus removing the points of painful impingement during abduction The subacromial bursal sac is also resected because one frequently finds secondary inflammatory changes within the bursa. *Most often*, these changes are associated with lesions on the bursal side of the cuff.

COMPLETE TEARS Numerous methods have been devised for repair of these lesions here McLaughlin's technic, which has obtained excellent results, will be described (Fig 8) Briefly the repair is by excision of the peripheral margins of the defect and side-to-side *repair up to, but not beyond, the point* of tension. The retracted portion of the cuff is then inserted into the humeral head at whatever point it will reach without tension when the arm is at the side

The same approach is used here as in incomplete tear repairs. The acromion is osteotomized in an oblique manner anteriorly to the acromioclavicular joint. *The tear is then excised back to healthy* tissue, leaving a V-shaped defect, the apex of which usually points medially This is approximated by means of a continuous shoelace type of suture starting at the apex of the V This leaves a small hiatal type of defect after approximation with the suture Just beneath this hiatus, the articular cartilage is removed from the humeral head so as to expose raw bone. Drill holes are placed from the exposed area through the greater tuberosity The continuous shoelace suture is placed through these holes and tied. Frequently, additional mattress sutures may be put in place further to strengthen this attachment

This type of repair of necessity has to be altered according to the lesion As in procedures for incomplete tears, *the tip of the acromion is removed*, the coracoacromial ligament is divided and in all cases the bursal sac is excised.

MASSIVE AVULSION OF THE CUFF

The same type of repair is used here as for complete tears (Fig 9) Frequently it is impossible to reinsert the cuff on the greater tuberosity In these cases it is inserted at some point on the humeral head so as not to be under tension This acts as a suspensory ligament for the humeral head and also increases the efficiency of the rotator muscles Theoretically a Nicola procedure patient then becomes ambulatory and is started on gravity free pendulum exercises These exercises are to be done every hour for three to five minutes They must be well regulated and closely supervised, never to exceed the tolerance of pain or fatigue When the pain subsides and strength gradually returns wall crawling exercises are started but active elevation is never permitted be

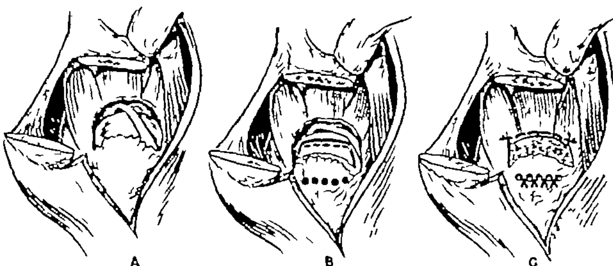


FIG. 9 Repair of massive avulsion of the cuff with advanced retraction (after McLaughlin) Approximation of the lateral edges of the defect may not be possible freshened edge of the cuff is then attached to the humeral head at whatever point it reaches without tension. (A) The transacromial incision adequately exposes the defect in the cuff. (B) The edges of the cuff are freshened back to healthy tissue, and the articular cartilage is removed from the head of the humerus to provide a raw bony bed. (C) The cuff is reattached to the raw bony surface by mattress sutures passed through drill holes and tied in the outer surface of the greater tuberosity

would add stability but this has been found unnecessary If the avulsion is so massive and retracted so as to prevent any type of cuff fixation, a glenohumeral arthrodesis may be necessary This infrequently is the case

Postoperative Management of Cuff Repairs This phase varies depending upon the type of lesion and the repair used subsequently The arm is placed in balanced suspension until wound healing is complete During this phase gentle motion is permitted. The fore elapse of a three week period. Only the surgeon who has the exact knowledge of what has been done should dictate when active use of the arm should be begun

Concomitant Lesions with Rupture of the Musculotendinous Cuff As one of the goals in the early treatment of cuff tears the last mentioned was prevention of disturbing sequels. Unfortunately these are inevitable at times The most frequently seen are bicipital tenosynovitis tendinitis of rotator

tendons predisposing to a frozen shoulder calcareous tendinitis, bursitis, and formation of exostoses

BICIPITAL TENOSYNOVITIS This distinct entity may be a secondary sequel or may be caused by the initial trauma It is understandable when the torn portion of the cuff irritates the groove through which the tendon passes that there will be inflammatory changes Often a cuff tear will heal but the presence of a secondary bicipital tenosynovitis will cause persistence of the symptoms

TENDINITIS OF ROTATOR TENDONS The characteristic feature of a cuff tear is restriction of the normal arcs of motion of the shoulder With this restriction, if over a sufficient period, one will find the features of a tendi vascular and lymphatic stasis, fib contracture, and shortening of surro ing tissues This includes, of course capsule, the adductor and rotator cles and the biceps tendon. The cli picture is then one of a frozen shou

CALCAREOUS TENDINITIS Calcar deposits have been noted accompan or following musculotendinith cuff t It is a true indication of degener changes in the tendon fibers

BURSITIS Constant irritation of subacromial bursa by cuff tears par larly those on the bursal side or c plete tears, leads to bursal changes c prising villi formation, adhesions, thickening of the walls The burs richly supplied with sensory nerve fil

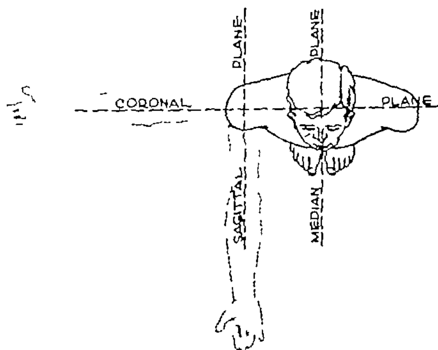


FIG. 10 Planes through or in relation to which the arm moves at the shoulder join (Codman The Shoulder p. 40)

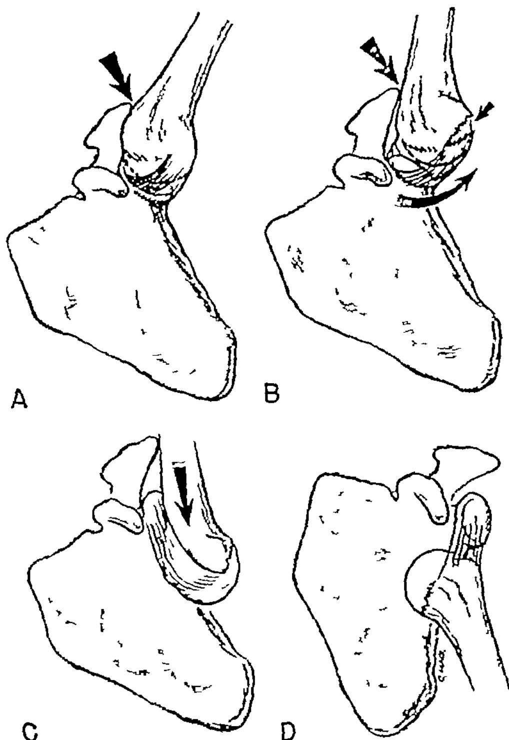


FIG. 11 Mechanism of production of acute traumatic dislocation of the scapulohumeral joint by hyperabduction of the arm. (A) Arm in the pivotal or safety position. (B) Humerus is forced into hyperabduction impinging against the acromion which acts as a fulcrum and levers the head of the humerus out of the glenoid cavity—note the tearing away of the inferior portion of the capsule from the neck of the humerus. (C) Head leaves glenoid fossa through rent in capsule stretching the rotator cuff across the glenoid cavity. (D) Arm at the side with head of humerus assuming first a subglenoid position.

thus, when the bursa impinges during elevation there is not only mechanical obstruction but obstruction due to pain It is for these reasons it is excised at the time of operative repair of cuff ruptures

EXOSTOSES Exostoses occasionally form on the greater tuberosity at the site of a cuff tear Impingement against the acromion or coracohumeral ligament during elevation elicits pain and a jog The treatment is excision.

DISLOCATIONS OF THE SHOULDER JOINT

The shoulder joint comprises four articulations (1) Scapulohumeral (2) sternoclavicular (3) acromioclavicular and (4) scapulothoracic joints. Dislocations of only the first three will be discussed

DISLOCATION OF THE SCAPULOHUMERAL JOINT

General This ball and socket joint is comprised by the articulation of the humeral head and the glenoid cavity The spherical humeral head rests on the shaft of the humerus at an angle which directs the articulating surface of the head upward, backward, and medially Only a small portion of the head articulates at any one time with the glenoid cavity The glenoid cavity is a shallow fossa shaped like an inverted comma and covered by hyaline cartilage The cavity faces upward and forward The periphery of the cavity is surrounded by the labrum glenoidale, a fibrocartilaginous structure. The glenohumeral ligaments as well as the long head of the biceps tendon are continuous with the labrum on the anterior and superior borders respectively

Several anatomic and functional features of the shoulder are responsible for the frequency of dislocations of this joint. Anatomically the bony architecture of the joint favors instability As was mentioned, only a very small area of the humeral head articulates with the shallow glenoid cavity at any one time The fibrous capsule and reinforcing capsular ligaments are relatively lax, of necessity to allow a wide range of motion The joint, due to its unprotected position, is vulnerable to direct as well as indirect trauma Functionally the integrity of the joint is dependent upon a delicate intricate system of neuromuscular balance and coordination Any force or motion disturbing this system will usually result either in dislocation or fracture

Dislocation of the scapulohumeral joint is a frequent lesion approximately forty to sixty per cent of all dislocations occur at this joint.

Mechanism of Production of Dislocations The scientific analysis of this mechanism was first done by Codman and is still the accepted theory When the arm is raised, the capacity for rotation diminishes in direct proportion to the length it is elevated When the arm is in complete elevation, the tuberosities and processes will be in a locked position so called "pivotal position" (Fig. 10) To reach the pivotal position in the sagittal plane the arm must be internally rotated and in the coronal plane externally rotated

One notes on elevation of the arm in external rotation that a block is encountered. This is impingement of the humeral head on the acromion preventing further elevation Any motion or force to the arm which does not permit proper rotation will usually result in dislocation or fracture The type of dislocation depends on the direction of the disruptive force (Fig 11) Anterior dis-

locations usually occur if hyperabduction is continued past the pivotal position or if normal rotation is prevented above the horizontal. Posterior dislocations usually occur below the horizontal when internal rotation is continued past the locked position.

The commonest injury is falling on the outstretched arm which results in a telescoping, impacting force of the head against the glenoid cavity and if of sufficient violence it will force the humeral head onto the anterior surface of the neck of the scapula, usually in a subcoracoid position (Fig. 12)

Types of Dislocations. The position of the humeral head in relation to the glenoid cavity determines the type of dislocation (Fig 13) They may be either acute recurrent, or old.

1 Anterior dislocations
   a Subcoracoid. Head is below the coracoid process It is the commonest type of all dislocations
   b Subglenoid. Head is below the

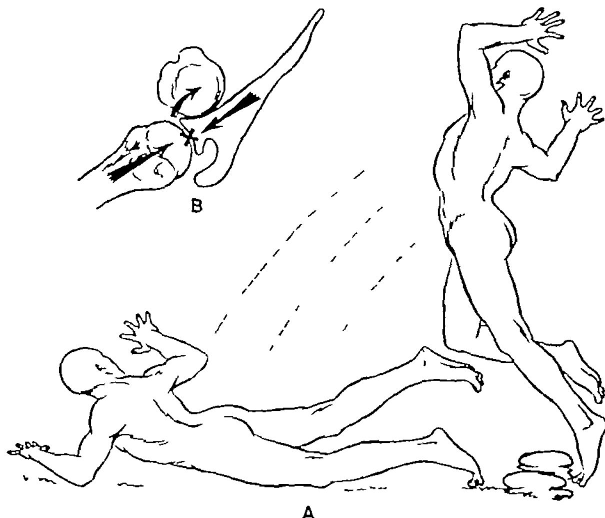


FIG. 12. (A) Dislocation caused by fall on outstretched arm producing an impacting force against the glenoid cavity (B) Resultant force is created which acts through the plane of glenohumeral joint and allows head to dislocate anteriorly on the neck of the scapula in a subcoracoid position.

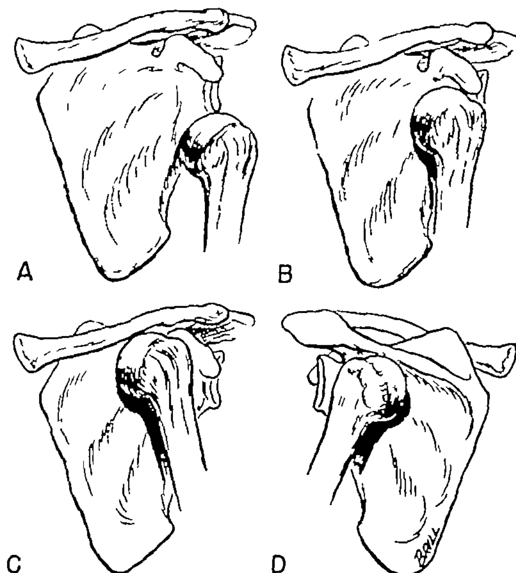


FIG. 13 Four types of dislocation of the scapulohumeral joint. (A) Subglenoid dislocation (rare type) (B) Subcoracoid dislocation (commonest type) (C) Subclavicular dislocation (rare type) (D) Subspinous dislocation (rare type)

glenoid cavity This is actually an inferior dislocation but it usually becomes a subcoracoid type (Rare)

c Subclavicular Head is below the clavicle (Rare)

2. Posterior dislocations

a. Subspinous Humeral head is just below the scapular spine (Rare) Often it is difficult to diagnose

3 Luxatio erecta dislocation

The arm is completely abducted with the humeral head below the glenoid cavity (Very rare)

Acute Anterior Dislocations. Acute traumatic anterior dislocation is the commonest type of dislocation of the glenohumeral joint The most frequent type of trauma is that of falling on the outstretched arm.

PATHOLOGY There has been con-

siderable disagreement as to the actual pathology in these lesions Heretofore it was believed that avulsion of the labrum glenoidale, the fibrous capsule and the glenohumeral ligaments from the anteroinferior aspect of the bony brim of the glenoid fossa, were the most frequent lesions encountered

Recent study based on direct vision of acute dislocations rather than on postulation, was done on eighteen fresh anterior dislocations before reduction Of these cases, sixteen were of the subcoracoid type and two were of the subglenoid type

These observations are divided into two categories

1 Head lies outside of capsule (six cases)

The capsule was stripped from the humerus neck in four cases and, associated with this, were tears of the subscapularis tendon in two cases. The labrum and glenohumeral ligaments were intact. The remaining two cases revealed massive cuff tears with displacement of the biceps tendon. There were no abnormalities of the fibrous capsule labrum glenoidale, or the glenoid rim except those due to degenerative changes compatible with their age (both over sixty years of age) and senescence.

2. Head lies inside capsule (twelve cases)

All cases revealed severe stretching of the subscapularis muscle with superficial tearing. All rotators were under great tension in each of the twelve cases. Four cases revealed complete tears of the cuff. Usually the inferior and the middle glenohumeral ligaments showed evidence of severe trauma or were ruptured. The labra were separated from the anterior portion of the glenoid rim in six cases although the capsule was intact on the neck of the scapula In three of these cases the labra were shredded. In all twelve cases the head came to rest in the subscapularis recesses of the fibrous capsule

Clinical Features of Acute Anterior Dislocation 1 Incidence The lesion usually affects young males in the last part of their teens and after twenty years of age Females, occasionally and children, rarely are involved. Athletes are particularly susceptible The lesion comprises forty to sixty per cent of all dislocations

2 Trauma. There is a history of injury even slight, always present.

3 Pain. Pain is spontaneous with injury and is accentuated by any type of motion.

4 Impaired function. The arm is fixed in a position of slight abduction with the forearm flexed and internally rotated Active and passive motion is lost.

5 Appearance. The shoulder is flattened with prominence of the acromion, the axillary folds are fuller and lower the length of the arm appears longer than the unaffected side There is fullness in the subcoracoid region The patient lists to the affected side

6 Palpation reveals the absence of the humeral head in its normal position adjacent to and below the acromion. On slight rotary motion of the arm the head motion is palpable in the subcoracoid region

7 Included in the clinical examination one must carefully note any sensory changes of the skin, loss of muscle power in the forearm and hand which suggest brachial plexus damage, and possible vascular changes.

Roentgenographic Examination It is essential that an x-ray examination be done before any type of therapy is instituted. The purpose is *twofold*, to

establish the type of dislocation and to reveal concomitant fractures which would alter the management (Fig 14) Both lateral and anteroposterior (including stereoscopic) views should be taken. The lateral views clearly depict lesser is prominent on the medial inferior surface of the head.

TREATMENT Before any type of therapy is instituted, there must be a full and thorough evaluation of all possible complications The objectives of



FIG. 14 (Left) Characteristic features of the normal glenohumeral articulation with the head of the humerus rotated externally Note the prominent lateral border of the head formed by the greater tuberosity: the lesser tuberosity is medial and parallel to it, while the intertubercular sulcus is visualized between the two. The glenoid fossa casts a crescent shadow over the medial articular surface of the head. The rounded articular surface of the head covers the inferior region of the glenoid fossa. (Right) Characteristic features with the humerus rotated internally The greater tuberosity is barely distinguishable, while the lesser appears to be in the glenoid cavity The inferior portion of the glenoid fossa is covered by the tuberosities. Note that the rounded articular surface of the head is directed upward and outward.

the relation of the humeral head to the glenoid cavity In this type of dislocation one notes the head in a subcoracoid position The humerus is internally rotated as indicated by the rounded articular surface of the head bein- rected upward and usually outwa- greater tuberosity is usually in- guishable due to the rotation ...

reduction are reduction without further trauma to surrounding and involved structures, maintenance of the reduction and restoratio- ...al function

Closed Metho- ... on. Recent ... locations, if ... most fre- ... are ea- ... by minimal provided ... spasm ... is ...

effected by a general anesthesia which should be used in all reductions In all types of reduction where rotary motion is used, it must be remembered the arm is a strong lever which predisposes the shoulder to fractures, soft tissue damage and neurovascular damage during the manipulative procedure The following methods are described

1 Traction on adducted humerus is laid across the abdomen at right angles to the slightly adducted humerus (Fig. 15)

2 Kocher s maneuver This procedure is basically a series of rotary motions in an attempt to retrace the pathway of the dislocation into its normal position One is justified in its use if the straight traction method fails or if the dislocation is of old standing where

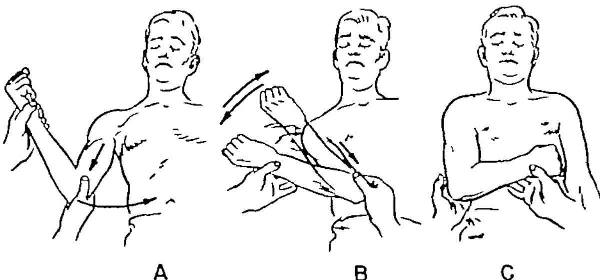


FIG. 15 Reduction of dislocations of the scapulohumeral joint by steady traction on the humerus, first in the plane in which it lies in relation to the trunk (A) Traction is maintained while the arm is carried into a slightly adducted position this usually effects reduction. Occasionally it may be necessary to rotate gently the arm externally and internally (B) After reduction, the arm is gently laid across the chest (C)

The patient lies on his back using the body as countertraction. The operator then applies straight traction to the slightly adducted humerus either with the elbow flexed or extended. Traction is exerted until the head is in a subglenoid position. Slight rotary motion (rocking) may be used if necessary To reiterate, force must not be used. There is advantage to flexing the elbow in that it relaxes the biceps tendon and the neurovascular bundle thereby eliminating the possibility of damage to these structures After reduction, the forearm force is necessary to overcome soft tissue contractures.

The patient is in the same position and the same type of traction is applied at the elbow which is flexed at approximately ninety degrees The humerus is in slight abduction. After a stretching phase, three rotary motions follow

a. External rotation of the humerus to its limits of rotation.

b Forward adduction Maintaining traction and external rotation, the elbow is brought to the midline of the body This procedure effects the reduction.

c Internal rotation Maintaining traction and position of the elbow the hand is placed across the opposite shoulder and immobilized in that position

3 Hippocrates method Traction and leverage with a foot in the axilla This method is mentioned only to be condemned Straight traction in a slightly adducted position of the humerus is applied with both hands at the wrist. The elbow is extended The operator s bared foot is in the axilla Slight rotating motion frequently is necessary to effect reduction

4 Nicola procedure The patient is in a sitting position with the elbow flexed at ninety degrees in the sagittal plane and externally rotated Downward traction is applied at the elbow while the other fist is placed in the axilla using it as a fulcrum to lever the head into the glenoid cavity

Postreduction Management of Closed Reductions Heretofore the two prime considerations in the management were the prevention of a frozen shoulder and or recurrence A very high percentage of dislocations occur in young men in their late teens or twenties but ironically frozen shoulders rarely occur in patients under thirty years of age Hence in the younger age group the problem is only prevention of recurrences

Reiteration of the findings listed under the pathology of dislocations of the glenohumeral joint brings to mind the constant findings of severe damage to the short rotator muscles

With stability of the rotator cuff and muscles recurrences may be prevented thus management should be in that direction The best for this purpose is the Nicola apparatus which restricts abduction elevation and all rotary motions The elbow and hand are free This fixation is maintained for eight weeks after which the patient is started on gradual motion in the stooped position then wall crawling exercises and use of the arm within an arc of painless motion and fatigue are commenced Thus second phase should be over a period of four weeks At the end of twelve weeks one should expect complete return of function

In the older age group the presenting problem is that of a frozen shoulder Immediately after reduction, they are placed in either a sling or cuff and collar They are started immediately on gravity-free pendulum exercises. Care must be taken to stay within the arc of painless motion. Abduction beyond forty five degrees for the first two weeks is not permitted The second two weeks motion may be carried to the horizontal After this period, use may be instigated according to the type and extent of the dislocation If there has been extensive stretching of the soft tissue the rapidity of the course of therapy will be lessened Optimum functional results should be attained in eight to ten weeks

Open Reduction for Acute Dislocations The commonest causes for failure of closed reduction are interposition of a portion of the cuff or the inferior capsule between the glenoid cavity and head of the humerus and posterior displacement of the biceps tendon The above and the presence of a fracture are the criteria for open reduction

A transacromial approach (McLaughlin) is used which affords excellent exposure of the joint space without risk to the axillary nerve After removal of the interposing soft tissue reduction is effected by gentle traction on the humerus in slight adduction If the biceps tendon is avulsed from the groove it is likely to develop a tenosynovitis

The biceps tendon is divided at its insertion into the glenoid cavity and transplanted to the coracoid process Bicipital tenosynovitis, which is a common complicating feature of dislocations, may be more disabling than the primary lesion, thus prevention is surely justified.

Ruptures of the cuff when found are repaired in the same manner as previously described

Postoperative Management The postoperative management is dependent upon the amount of reparative surgery which was necessary If only reduction of a dislocation was performed, the same type of management as applied to the closed reductions are instituted.

Acute Traumatic Posterior Dislocations In contrast to the anterior dislocations this lesion is quite rare and therefore is overlooked on many occasions Most frequently the trauma is that of forceful dorsiflexion with the arm internally rotated or direct trauma to the anterior aspect of the shoulder

PATHOLOGY Due to the rarity of the lesion, statistics on direct observation of acute posterior dislocations are wanting. One can postulate with accuracy after observing anterior lesions that the humeral head may be forced through a rent in the musculotendinous cuff or the labrum the capsule and the rotator muscles may be stripped off the posterior surface of the neck of the scapula with the head lying beneath them in an intracapsular position. The dislocation may be either extracapsular or intracapsular Observations of recurrent posterior dislocations indicate redundancy of the capsule or a rent in the same Whatever the associated pathology it is readily understandable that stretching and tearing of the surrounding soft tissues occur

CLINICAL FEATURES OF POSTERIOR DISLOCATIONS 1 Incidence No age groups are particularly affected

2. Trauma. This may be in varied form epilepsy and electric shock therapy have been listed as causes

3 Pain. All motions are painful.

4 Impaired function The arm is held in adduction occasionally depending on the position of the head in a subspinous position, it may be slightly abducted and forward.

5 Appearance. Usually there is a large degree of swelling The front of the shoulder is flattened with prominence of both the acromion and the coracoid process. The head, which is palpated as a globular mass is posterior and moves with rotation of the arm

6 Sensory and vascular changes must be carefully noted as these may be associated features indicating severe injury

ROENTGENOGRAPHIC EXAMINATION Using the criteria as previously described, here the humeral shaft lies in full internal rotation, thus the lesser tuberosity forms the lateral margin of the head. On the lateral view the head is in a subspinous position in relation to the glenoid cavity (Fig 16)

TREATMENT *Closed Method of Reduction.* The rarity of this lesion warrants only one description of type of reduction Traction is applied to the humerus as in the first method described for anterior dislocations The elbow is in a flexed position After steady traction brings the head down to the brim of the glenoid fossa, the humerus is then adducted and internally rotated, neither motion being forceful. Occasionally pressure on the head in the path of reduction may help General anesthesia should be used.

Open Method of Reduction. The same

type of open reduction is employed for posterior dislocations as for anterior reduction. The criteria for using an operative procedure are also essentially the same.

Postreduction Management Again the period of immobilization and the exercise program for return of function parallels that previously described. Recurrent dislocations are a complication of these dislocations as well. J C Wilson and F M McKeever have devised a method of stabilizing the glenohumeral joint following reduction Two wires which cross each other are passed through the acromion and humeral head. These wires are left in position three weeks and then removed (Fig 17)

Luxatio Erecta The pathology of this lesion is obvious in that the head is in an infraglenoid position with the humerus fully abducted The method of reduction is by gentle upward and slightly outward traction on the arm

Postreduction management is the same as for the above types of dislocations

Complications of Acute Dislocations. A dislocation is not merely a disruption of the joint it implies damage to the surrounding soft tissues neural and vascular structures It is of utmost importance that a thorough clinical examination along with roentgenographic study be made both before and after reduction



Fig. 16. Posterior dislocation. Note the loss of outline of the greater tuberosity The lower portion of glenoid cavity is exposed and no longer covered by the spherical articular surface of the head in normal external rotation and the tuberosities in internal rotation.

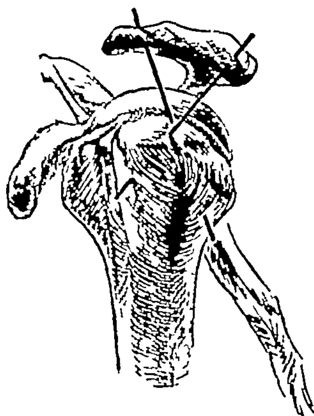


FIG. 17 Method to maintain position following reduction of posterior dislocations which tend to recur (Wilson and McKeever)

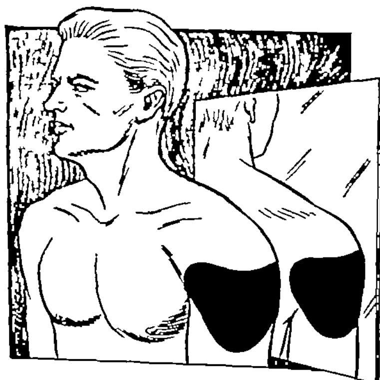


FIG. 18 Area of hypoesthesia, or sensory loss, following injury to circumflex nerve

The most frequent associated lesions are

1 Rupture of the rotator cuff the extent of which may vary from an incomplete tear to a complete avulsion of the cuff

2 Dislocation of the biceps tendon. This may be the etiology for the onset of bicipital tenosynovitis which can ultimately be as disabling as the primary lesion

3 Fractures. X rays are mandatory in that all types of fractures may be incurred fractures of the humerus, humeral head, and glenoid rim are most commonly seen

4 Brachial plexus injury The axillary circumflex nerve is the most vulnerable and frequently involved of all nerves in the brachial plexus Frequently pain and muscle spasm mask loss of motor power in the deltoid If this is the case the significant finding will be the presence of a path of hypoesthesia in the sensory distribution of the sensory portion of the nerve (upper lateral cutaneous nerve) (Fig 18) The return of sensation or motor function is dependent upon the severity of the injury Only rarely does a residual circumflex palsy result. The musculocutaneous nerve is the second most involved nerve It manifests itself by paralysis of the biceps brachii the coracobrachialis, and the brachialis muscles or by sensory loss over the lateral aspect of the forearm

5 Vascular injuries This type of complication may be sustained at the time of injury or at the time of reduction The latter particularly if there is a concomitant fracture which severs the vessels on manipulation These are diagnosed by the presence of a hematoma cyanosis of the arm and the decrease or absence of the radial pulse

These complications are so often not as severe or not present at the time of injury but rather are sustained or increased in severity by manipulation. It is all important to do adequate evaluation both before and after reduction.

Old Dislocations Long standing unreduced dislocations of the glenohumeral joint present a varied picture in that the duration and extent of injury in each case is so different Before one considers any type of treatment such factors as the age of the patient, the severity of the symptoms, the degree of disability and the duration of the lesion must be evaluated as to the need for therapy As a rule better results are obtained with closed procedures and in the earlier lesions The prognosis is guarded in all cases

Old dislocations are more than just dislocations of the glenohumeral joint there are present secondary changes in the surrounding soft tissues which make reduction and maintenance of reduction very difficult. Depending on the duration of the lesion, there are varying degrees of fibrosis contracture and shortening of all involved tissues Recalling the pathology of acute dislocations the musculotendinous cuff and the fibrous capsule are particularly involved The synovial cavity is obliterated by scar tissue Frequently the biceps tendon is completely severed and has reattached itself below the lesser tuberosity In late cases there are marked bony changes fibrillation to complete disintegration of the articular cartilage marked demineralization and atrophy of all parts of the joint With these changes in mind the difficulties surrounding treatment of this type of dislocation are readily understandable

Treatment Most often this lesion is associated with considerable pain and

disability but occasionally the pain lessens with time and impairment of function is not too great. Considering the wide variance of cases, one has several avenues of approach to treatment.

1. Physical therapy. No attempt is made to reduce the dislocation but rather just to improve function. Most frequently used in the very older patient.

2. Closed manipulation. This method is used in those cases less than three months duration but is usually preceded by a period of skeletal traction to overcome contractures.

3. Open reduction. All cases which are over three months duration and those treated unsuccessfully by closed methods.

4. Arthrodesis of the joint. This is used in cases exhibiting high degree of bony changes, particularly in young individuals.

5. Resection of the humeral head. Particularly used in the older patient with a very painful shoulder and in the presence of aseptic necrosis of the head due to stripping of the soft tissues.

Closed Methods. A combination of the same procedures as is used for an acute dislocation is used here. Complete relaxation is essential; this is best effected by general anesthesia. Steady traction on the arm with the elbow flexed is maintained for a period long enough to mobilize the humeral head. The humeral shaft is then rotated internally and externally to free adhesions. The arm is then abducted and externally rotated slowly. The foregoing procedures free the head and overcome soft tissue contracture to permit reduction. The reduction is then effected by the Kocher maneuvers. If reduction is not successful after two attempts, an open method should be employed. In reducing this type of dislocation, force must be used, but only in the hands of a skillful operator. It is in these cases that irreparable damage may be done to the brachial plexus and to the vascular structures of the axilla.

Open Methods. An approach which affords excellent exposure is a combination of the incision of Thompson and

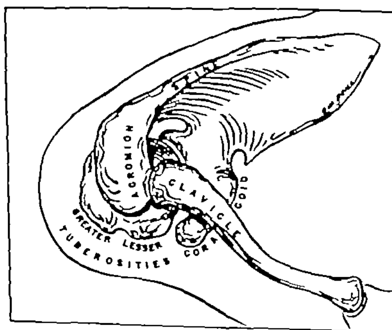


FIG. 19 Bony Landmarks of the shoulder girdle.

Henry and that of Cubbins (Fig. 19) The skin incision extends along the anterior border of the deltoid muscle beginning at the junction of the outer and middle third of the clavicle and ending proximal to the deltoid tuberosity The horizontal limb of the incision extends from the inferior surface of the acromioclavicular joint medially along the anterior surface of the clavicle so as to connect with the vertical limb The cephalic vein and the thoracoacromial artery should be retracted medially with the pectoralis major muscle and a portion of the anterior fibers of the deltoid muscle The deltoid is reflected laterally after dividing the clavicular head from the outer third of the clavicle with an osteotome Division of the coracoacromial ligament permits full exposure of the subscapularis tendon and muscle. The deltoid may be further divided posteriorly by means of an osteotome from the acromion process and the spine of the scapula. This latter extension permits visualization of all aspects of the shoulder By dividing longitudinally the rotator cuff in the posterior portion just proximal to the greater tuberosity full visualization of the glenohumeral joint is possible *Because of the associated pathology in old dislocations* the pertinent factors to be kept in mind are adequate exposure of the area, cleaning the glenoid cavity of all scar tissue and severance of the subscapularis tendon When doing the latter care must be taken not to injure the axillary nerve which lies posteriorly

After exposing the area and the dislocation the subscapularis muscle is divided just proximal to its insertion. This usually permits enough mobilization to reduce the humeral head. The glenoid fossa is cleaned of scar tissue By means of the Kocher maneuvers the head is reduced. The tendons and capsular defects are resutured

Many methods of maintenance of reduction may be used The Nicola procedure passes the head of the biceps through a tunnel in the humeral head and reattaches it to the coracoid process This then acts as a suspensory ligament. The coracohumeral ligament may be used likewise A vitallium transfixion screw from the humeral head through the glenoid cavity for a three to four week period is used by Neviaser

The method of Wilson and McKeever using two transfixing Kirschner wires is very good (Fig 17)

When none of the above is used, the arm should be casted or splinted at sixty to eighty degrees midway between a coronal and sagittal plane After a six week period graduated exercises are begun.

A satisfactory result is considered when there is painless abduction of the glenohumeral joint to sixty degrees with good muscle power

Recurrent Dislocation of the Glenohumeral Joint A recurrent dislocation of the glenohumeral joint is not in itself a separate entity from an acute dislocation *It is an aftermath or recurrence of the latter* the difference being in the trauma involved and the amount of soft tissue damage sustained A recurrent dislocation is incurred frequently by no more than elevating the arm in external rotation *Often the patient is able to dislocate and reduce the dislocation voluntarily*

Pathogenesis The primary causative factor in recurrent dislocations is neuromuscular imbalance *particularly* of the short rotator muscles of the shoulder joint. *It is obvious that the* imbalance may follow any initial dislocation in which the short rotators,

and particularly the subscapularis muscle, are severely stretched or traumatized and which has not been treated adequately

The above concept is drawn on the basis of direct observations of fifty-six recurrent dislocating shoulders All cases had initially sustained some form of violent injury to the shoulder

cesses In so stretching these recesses usually the middle glenohumeral ligament and occasionally the inferior glenohumeral ligament are lacerated

With this mechanism it is understandable that in all of the cases the musculotendinous cuff reveals pronounced laxity with severe stretching of the short rotators and particularly the subscapularis



FIG. 20. Defect in the upper and outer aspect of the head of the humerus of a patient with recurrent dislocations.

As was pointed out in the discussion on ruptures of the musculotendinous cuff, the subscapularis recesses are out pouchings of the fibrous capsule onto the neck of the scapula. These recesses were present in 88 6 per cent of the cases. Unless the head either forces a rent in the anterior portion of the cuff or below the lower border of the subscapularis muscle the head in an anterior dislocation will lie in one of the two (usually present) subscapularis re-

muscle There appears little difference in pathology between the recurrent and initial dislocations The recurrent lesions show evidence of repair fibrous, and secondary changes of tissues indicating the very active reparative processes following a fresh dislocation.

Prior to the concept as above understood, Bankhart postulated the pathology in all recurrent dislocations was either a detachment of the labrum from the anterior glenoid brim or tearing

away of the capsule from the labrum. In the series of fifty six cases eighty five per cent revealed some degree of detachment of the labrum and fibrous capsule In fifteen per cent of the cases the labrum was firmly anchored to the glenoid margin by its capsular border however the glenoid border was free like a meniscus Many of the detached labra revealed advanced degenerative changes This concept is not consistent with the variational anatomy as found in the above series of cases

Broca and Hartman were the first to note a defect on the posterior aspect of the humeral head which they believed facilitated recurrent dislocations (Fig. 20) thirty-seven of the fifty-six cases were studied roentgenographically and only sixty two per cent revealed any evidence of such a defect.

In accepting a concept of pathogenesis for recurrent dislocations there must be a correlation between the incidence and pathology present. Recurrent dislocations are common in the earlier decades but rare after the fourth decade It has been shown that labral detachment is a frequent finding after the third decade and after the sixth decade is demonstrable in approximately 100 per cent of cases It is reasonable to assume detachment is associated with advancing age at which time recurrent dislocations are rare

Recurrent dislocation is a self limiting disease in that people are afflicted in the second or third decade with decreasing frequency This is due to the early degenerative processes manifested by the musculotendinous cuff which begins to limit external rotation as early as the third decade in the normal shoulder Limitation of external rotation stabilizes the glenohumeral joint this is the goal of all operative procedures for this entity

Treatment The immediate treatment for a recurrent dislocation is the same as that for an acute or initial dislocation An important phase of this therapy is adequate and prolonged immobilization of the arm in internal rotation to prevent recurrent lesions The *treatment as described here includes* only the operative procedures for repair of recurrent dislocation. In choosing any of the following procedures to be done one must realize there is an alarmingly high percentage of failures. Reparative procedures are classified into three main categories (1) suspension operations, (2) bone block operations and (3) plastic procedures on the capsule and the tendons

I Suspension procedures A suspensory ligament is created from fascia or tendon for the humeral head which mechanically prevents dislocation or subluxation of the humeral head

A Nicola procedure Exposure of the head is made through an anterior incision extending distally 10 to 12.5 cm (4 to 5 inches) from the coracoid process The transverse humeral ligament is visualized after retraction of the deltoid muscle and divided. The long head of the biceps is exposed by dividing the capsule parallel with the fibers of the cuff The biceps tendon is then divided at the lower end of the bicipital groove after traction sutures (black silk) are placed in both segments A 6 mm. (¼ inch) tunnel is then made through the head of the humerus beginning at the bicipital groove and emerging through the center of the articular head. After stripping the synovialis from the proximal segment of the tendon the tendon is passed from above downward through the constructed tunnel The two segments are then approximated with black silk sutures This is then anchored

through drill holes to the transverse humeral ligament onto the sides of the groove The capsule is closed with side-to-side silk sutures

Postoperatively the arm is immobilized in a plaster Velpeaux dressing for four weeks (Fig 21) After the first four weeks pendulum and graduated exercises along with physical therapy are instituted for complete restoration of function.

Although a simple procedure to perform, and seemingly a logical method of prevention of dislocation, it is mechanically and anatomically unsound. Injury to the articular cartilage gives rise to internal derangement of the joint which very frequently causes pain following this procedure Snapping and clicking sensations are also noted during certain ranges of motion.

It should be recalled that through normal wear and tear the biceps tendon through its attachment to the labrum tends to tear the labrum from the glenoid rim This is a part of the Bankhartian theory of pathology of recurrent dislocation Surely then to add additional stress to its attachment to the labrum is defeating the very purpose of the procedure Labrum detachment is the commonest cause for failure of the Nicola procedure

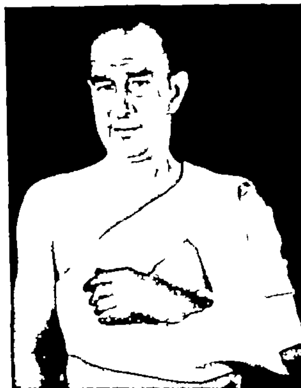


FIG 21 Plaster-of-paris shoulder swathe used instead of a Velpeau dressing to immobilize the arm.

B Henderson s tenosuspension procedure. A curved skin incision is made from the anterior to the posterior aspect of the shoulder joint. This is centered approximately 5 cm (2 inches) below the superior surface of the acromion process. The superior flap is retracted upward, exposing the acromion process and the deltoid muscle A trans

verse drill hole 10 mm. in diameter is made through the acromion process A similar drill hole paralleling the first, is made through the greater tuberosity A length of peroneus longus tendon 25 cm (10 inches) long and one-half the thickness of the *in situ* tendon is passed through both drill holes and sutured to itself side-to-side

Postoperatively the arm is immobilized by the side for ten days, after which the usual procedure of graduated exercises is instituted

This procedure has lost popularity in that a high degree of failures occurs particularly when fascial slings are used.

2 Bone block procedures The objective in this procedure is to present a bony block anteriorly to the humeral head to prevent dislocation Speed uses a tibial graft for this purpose Oudard used a bone graft extending in front of the glenohumeral joint from the coracoid process. This type of procedure meets with a high degree of technical difficulties

3 Plastic procedures on the capsule and tendons The objectives of this type of procedure are to prevent dislocation by creating a soft tissue barrier in front of the humeral head.

A Bankhart procedure The best exposure is obtained by McLaughlin's transacromial approach. The deltoid is partially detached from the clavicle exposing the coracoid process The tip of the coracoid is divided, retracting it downward with its muscular attachments By externally rotating the humeral shaft, the subscapularis tendon is brought into full view The interval between the capsule and subscapularis tendon is developed back to the anterior glenoid margin. The subscapularis tendon is divided 12 mm (½ inch) proximal to its insertion. The anterior margin of the glenoid rim and the capsule are identified The interior of the joint is exposed by a 5 cm (2 inch) vertical incision approximately 1 cm. (⅓ inch) from the glenoid margin hence creating a lateral and mesial capsular flap

After roughening the anterior surface of the glenoid with a curet, four drill holes are made in the rim The lateral capsular flap is then sutured to this area on the rim and the mesial flap overlaps this and is sutured to the lateral flap The subscapularis tendon is reapproximated as is the coracoid process The wound is then closed in layers

Postoperatively a plaster of paris shoulder swathe is used to immobilize the arm to the side for two weeks (Fig 21) The arm is then placed in a sling for two more weeks and exercises are begun. Motion above the horizontal is not permitted until the sixth week Forceful external rotation is prohibited during this period Restoration of motion should be attained in eight weeks

The basis for success for this procedure is restoration of the normal anatomy of the labrum and capsule by resuturing it. Many believe the success of this procedure actually is due to the limitation of external rotation by overlapping the anterior capsule

B Putti Platt operation (Fig 22) An anterior deltopectoral incision affords the best exposure The conjoined tendon (coracobrachialis and short head of the biceps muscle) is divided from the coracoid process The musculocutaneous and axillary nerves must be carefully avoided With the arm externally rotated, the subscapularis tendon is divided 2.5 cm (1 inch) from its insertion the capsule is also divided at the same level. The lateral flap of the subscapularis tendon is then sutured to the

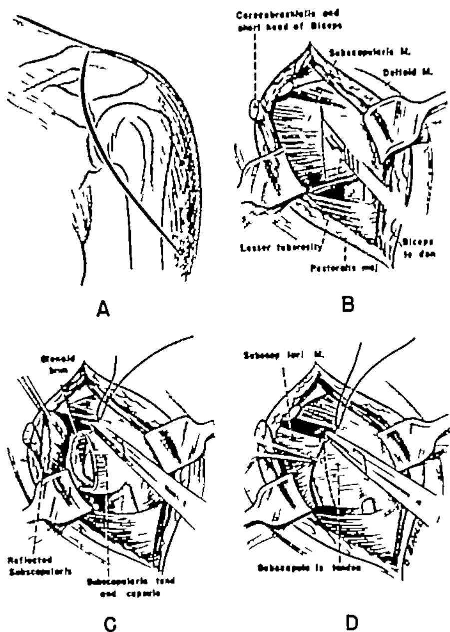


FIG 22. Putti-Platt Operation. (A) Anterior deltopectoral incision. (B) Conjoined tendon of the coracobrachialis and short head of the biceps tendon has been divided and retracted medially and downward. Subscapularis tendon is divided 1 inch from its insertion the incision is also carried through the fibrous capsule. (C) With the arm rotated internally the lateral flap of the subscapularis muscle is sutured to the soft tissues on the anterior surface of the glenoid rim or to the labrum or occasionally to the under surface of the capsule and the subscapularis muscle. (D) The medial capsular flap is sutured to the outer surface of the lateral subscapularis tendon, thereby overlapping the first suture line. Finally the medial subscapularis flap is tacked to the tendinous portion of the cuff

soft tissues on the anterior surface of the glenoid rim or to the labrum The capsule may also be included The lateral subscapularis flap may also be anchored to the anterior surface of the neck of the scapula The medial flap of the capsule is there plicated to the lateral subscapularis tendon flap The

medial subscapularis tendon flap is further plicated to the musculotendinous cuff or to the bicipital groove. The conjoined tendon is then reapproximated and the wound is closed in layers.

Postoperatively the management is the same as used in the Bankhart proce

major is then developed exposin subscapularis tendon when the a externally rotated

An incision is made in the in between the subscapularis and s spinatus tendons. The incision is s proximal to the blending of the

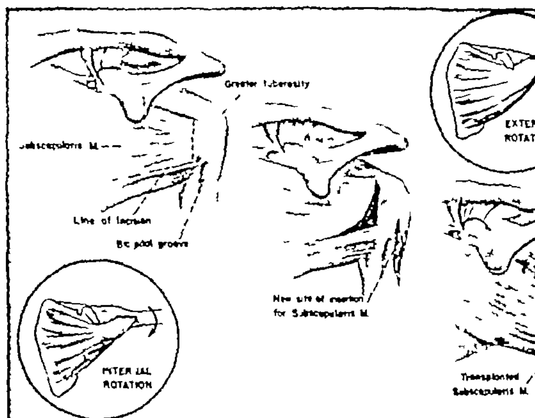


FIG. 23 Magnuson operation (modified) for recurrent dislocation. The end of subscapularis tendon is transferred to a bony trough below the greater tuberosity and para to the posterior lip of the bicipital groove.

dures. This procedure actually limits external rotation better than the Bankhart procedure but its theory is practically the same

C. Magnuson procedure (modified) (Fig. 23) An S-shaped skin incision is made on the anterior aspect of the shoulder beginning at the inferior margin of the acromioclavicular joint. The interval between the deltoid and pectoralis

scapularis tendon with the fibrous sule and carried to the anterior li the bicipital groove. A similar inci is made along the inferior border of subscapularis muscle. The tendo then divided by sharp dissection a insertion. By internally rotating the the greater tuberosity is easily vie By means of a suture passed thro the substance of the subscapularis

TABLE 1

ANALYSIS OF TWENTY-THREE MAGNUSON PROCEDURES (MODIFIED)

Name	*Sex*	*Age*	*Date of Operation*	*Number of Recurrences*	*Pain*	*Satisfied*
C.F	M	23	5/[illegible]6/48	1	Yes	No
R.M	M	[illegible]3	11/2[illegible]/47	0	No	Yes
R.C.	M	30	5/30/48	0	No	Yes
G.H	M	4	10/ 3/47	0	Occasionally	Yes
W.M	M	24	6/28/48	0	No	Yes
A.A	M	23	2/30/48	0	No	Yes
M.K.	M	21	3/[illegible]1/48	0	No	Yes
E.H	M	22	4/29/48	0	No	Yes
J.C.	M	29	6/25/48	0	No	Yes
J.F	M	[illegible]6	7/30/48	0	No	Yes
W.N	M	[illegible]0	7/19/48	0	Yes	Yes
A.N	M	[illegible]5	8/24/48	6	After Dislocation	No
W.S.	M	21	3/ 3/48	0	No	Yes
J.N	M	18	11/15/47	0	No	Yes
T.J	M	36	8/ 4/48	0	No	Yes
D.L.	M	17	5/21/45	0	No	Yes
W.B	M	30	1/21/48	0	No	Yes
C.M	F	29	3/[illegible]6/48	0	Slight	Yes
J.C.	M	19	8/24/47	0	No	Yes
L.B	M	33	6/12/47	0	No	Yes
T.N	M	22	8/18/46	0	No	Yes
D.O	M	9	10/15/47	0	No	Yes
J.N	M	[illegible]2	2/23/48	0	No	Yes

Analysis of Cases

Total number of cases	23
Age range	17 to 33 years
Males	22
Females	1
Recurrences of dislocation	2 (8.7 per cent)
Pain present	2
Not satisfied with operation	2
Sathfied with operation	21
Period of observation	17 months to 3½ years

pulled over to a point below the greater tuberosity below the level of its original insertion. It must not be under great tension. A groove is then made in the shaft parallel to the posterior lip of the sulcus approximately 6 mm (¼ inch) wide and as long as the width of the subscapularis tendon. The tendon is then buried in this trough and anchored by four silk mattress type sutures through drill holes in the posterior lip of the trough. The subscapularis muscle superiorly is sutured side-to-side to the supraspinatus muscle and inferiorly to the capsular tissues under the head of the humerus. The wound is then closed in layers.

Postoperatively the management is the same as for the Bankhart and Putti-Platt procedures. As a rule, abduction is restricted to a few degrees and external rotation to as much as eighty degrees. This restriction produces no functional disability but does assure against dislocation. In this procedure the subscapularis muscle and tendon fibers form a firm sling under the head during abduction and rotation. This

counterbalances the powerful pull of the adductor muscles which tends to force the head down and forward as in a dislocation

As was brought out before Nature's way of preventing recurrent dislocations is by gradual limitation of external rotation. *It is only logical to assume that* any procedure which limits external rotation will effect a cure The last described procedure the modified Magnuson is a simple procedure and is one which achieves that goal An analysis of 23 cases using the modified Magnuson procedure of repair revealed only two cases in which recurrent dislocation occurred following operation (Table 1)

Posterior Recurrent Dislocation Posterior recurrent dislocation may actually be recurrent due to undue stresses after initial traumatic dislocation or it may *be habitual dislocation* which occurs without a history of trauma and without undue stress A recurrent lesion may become habitual. Posterior recurrent dislocation either recurrent or habitual is frequently bilateral The latter may be seen in more than one member of a family

MECHANISMS OF DISLOCATION *Recurrent Dislocation.* This usually follows an acute traumatic dislocation and occurs when an undue stress is placed upon the arm The same mechanism applies here as for the initial posterior dislocation

Habitual Dislocation. This lesion most frequently occurs spontaneously without a history of trauma It occurs every time the arm is elevated in the coronal or frontal plane particularly if elevated in internal rotation

PATHOLOGY Essentially the same pathology is found here as in acute dislocation except that more pronounced laxity of the external rotators is seen rather than laceration. In posterior recurrent or habitual dislocation as seen in *acute dislocation, neuromuscular imbalance* is the most important factor to be considered in evaluating the pathology present.

TREATMENT By evaluating the status of the neuromuscular balance in this lesion one is able to determine the necessary procedure to correct the imbalance present One is able to cure these cases of posterior dislocation by advancing the insertion of the infraspinatus and teres minor tendons with the arm in external rotation. This tightens the external rotators thereby restricting internal rotation which *prevents* dislocation.

DISLOCATION OF THE ACROMIOCLAVICULAR JOINT

The acromioclavicular joint is a ginglymus *joint at the tip of the shoulder* made up by the articulating surface of the acromion and the distal articulating surface of the clavicle The stability of the joint depends on the coracoclavicular ligament (conoid and trapezoid) which is proximal to the acromioclavicular joint. The acromioclavicular ligament and the capsule of the joint add little to its stability as does the presence of a meniscus One must appreciate that the articulating surface of the acromion is beneath and posterior to the articulating surface of the clavicle therefore the *weight* of the upper extremity tends to pull the joint apart thus disruption of this joint is more easily understood.

Types of Dislocations. 1 Subluxation. Only the acromioclavicular liga*ment and the articular capsule are lacer*ated The coracoclavicular ligament remains intact (Fig 24)

2. Complete dislocation. In this lesion both the coracoclavicular and the *acromioclavicular ligaments along with*

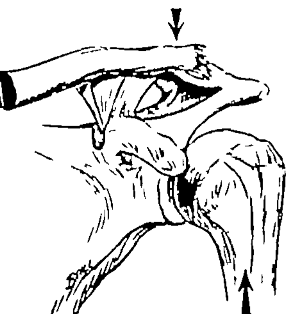


FIG. 24 Subluxation of acromioclavicular joint



FIG. 25 Dislocation of acromioclavicular joint.

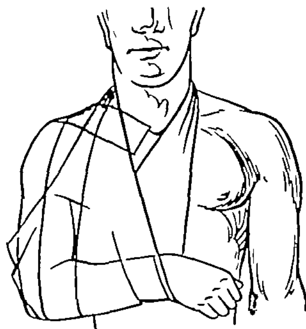


FIG. 26. Stimson adhesive dressing for subluxation of the acromioclavicular joint.

the capsule are disrupted. Occasionally the distal end of the clavicle is fractured wherein actually the acromioclavicular ligaments are not completely separated (Fig. 25)

Subluxation of the Acromioclavicular Joint. This lesion usually results from some minor degree of trauma. There is usually *prominence* of the acromion which is displaced anteriorly and of the clavicle which is displaced posteriorly There is some drooping of the shoulder on the affected side with point tenderness over the joint. Pain

may or may not be an important symptom.

X rays reveal distraction at the joint space The clavicle-coracoid relationship is not disturbed.

TREATMENT Adequate therapy for this type of dislocation is afforded with a Stimson adhesive dressing (Fig 26) Reduction is attained by tightly approximating the joint space by means of adhesive tape placed over the clavicle and around the elbow The pressure points are covered with felt and a cotton pad is placed in the axilla. Four or five strips of adhesive 10 or 12.5 cm (4 or 5 inches) wide are used Care must be taken to protect the skin The arm is suspended by a collar-cuff sling This type of immobilization is maintained for three to five weeks motion within the limits of the dressing is encouraged Physical therapy may be used favorably After removal of fixation, full range of motion is started.

Complete Dislocation of the Acromioclavicular Joint Most often a history of severe trauma associated with sudden drooping of the shoulder is elicited from the patient. The interval between the distal end of the clavicle and acromion is usually palpable as well as excess mobility of the end of the clavicle If the clavicle is fractured, the point of fracture is easily palpated By downward pressure on the clavicle and upward pressure of the elbow the deformity can be reduced

X rays reveal not only distraction of the acromioclavicular joint but also separation of the coracoclavicular relationship (Fig 27)



FIG. 27 Complete dislocation of the acromioclavicular joint. The interval between the clavicle and the coracoid process has been greatly increased.

TREATMENT Closed methods of reduction and maintenance of reduction of this lesion as a whole has been unsuccessful The surgical procedures described below are not without unfavorable sequels In reducing these dislocations as with all dislocations, the joint space must be free of interposing soft tissue Frequently the meniscus is lacerated or the ligaments are frayed either of which predisposes to painful arthritic processes if not removed prior to reduction.

1 Transfixion of the joint with wires A skin incision is centered over the

acromioclavicular joint exposing the distal clavicle and joint. The meniscus and ligaments are removed from the joint space so as to allow good approximation by manual reduction Two heavy Kirschner wires are then passed through the acromion crossing the joint space and into the clavicle for 25 to 37 mm (1 to 1½ inches) (Fig 28) The wires are cut so as to be under the skin but easily accessible for withdrawal The capsule and acromioclavicular ligaments are then repaired as well as possible

Postoperatively the shoulder is immobilized for a four week period with either a Velpeau or plaster swathe dressing Following this the arm is kept in a sling for two weeks The wires are then removed and the patient is allowed full range of motion

2 Reconstruction of the coracoclavicular ligaments In conjunction with the above the coracoclavicular ligament is reconstructed, using the conjoined tendon of the short heads of the biceps and the coracobrachialis muscles (Fig 29) This is a modified method of the Vargas technic. Through an S-shaped incision extending from the tip of the acromion along the clavicle and skirting the outer edge of the coracoid process the deltoid anterior fibers are divided longitudinally The deltoid muscle is divided transversely at the lower margin of the clavicle so as to expose fully the conjoined tendon The conjoined tendon is then split in half longitudinally for the extent of its tendinous portion The outer half is divided transversely leaving the proximal portion attached Transfixion of the acromioclavicular joint with two Kirschner wires is then done as described above. The freed flap of the conjoined tendon is passed subperiosteally around the clavicle as a loop or sling and is sutured to itself The enveloping periosteum is then sutured to the tendinous sling.

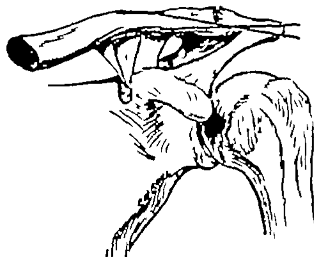


FIG. 28 Transfixion of acromioclavicular joint by two threaded wires.

Postoperatively the shoulder is immobilized for a six week period in a plaster of paris shoulder swathe after this period, graduated exercises are begun The wires may be removed at the end of ten to twelve weeks

Some operators use strips of fascia lata to reconstruct the ligament but are met with calcification of the reconstruc

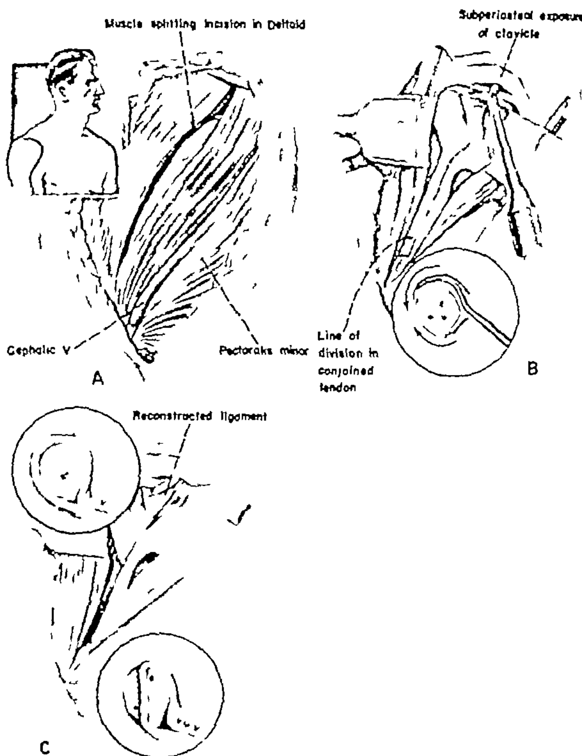


Fig. 29 Reconstruction of coracoclavicular ligament (Vargas modified)

tion as a complication In fact all such procedures around this joint frequently encounter synostosis which limits function and accounts for considerable pain and stiffness

3 Excision of the outer end of the clavicle Through a curved incision the distal clavicle and acromioclavicular joint are exposed The distal 3 7 cm (1½ inches) of the clavicle is resected after reflecting the periosteum The joint space is cleared of all ligaments and the meniscus The reflected periosteum is then sutured to itself covering the raw surface of the clavicle

Postoperatively the shoulder is immobilized for approximately one week for soft tissue repair Following this graduated exercises and physical therapy are begun The goal is to attain full muscle power with stability Usually in four to six weeks optimum restoration of function is attained

This procedure was originally used in chronic dislocations but now is being used widely in acute dislocations, particularly in those patients not required to do heavy labor

4 Transfixion of the coracoid process and the clavicle with a screw Bosworth Vere Hodge and Watson-Jones maintain reduction by passing a lag screw through the clavicle into the coracoid process This procedure is undesirable in that it restricts elevation of the arm because of the elimination of acromioclavicular motion.

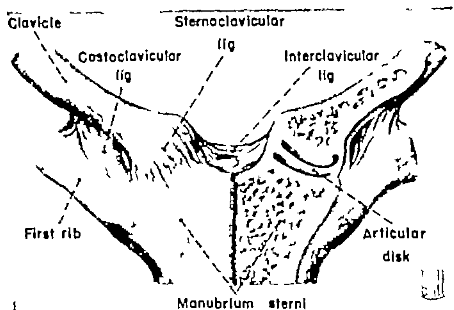


FIG. 30 Coronal section of the left sternoclavicular joint. Observe that the joint is divided into two compartments by the fibrocartilaginous disk. The articular end of the clavicle and the sternum are covered by fibrocartilage instead of hyaline cartilage. The interclavicular and the costoclavicular ligaments add to the stability of the joint. (Redrawn from S. W Spalteholz Hand Atlas of Human Anatomy Philadelphia Lippincott.)

TREATMENT OF OLD DISLOCATIONS As in all chronic lesions about the shoulder joint, full evaluation of motion or pain present in relation to the patient and his needs is essential Resection of the end of the clavicle is the method of choice in older patients those patients not requiring a powerful shoulder and in cases where pain is the

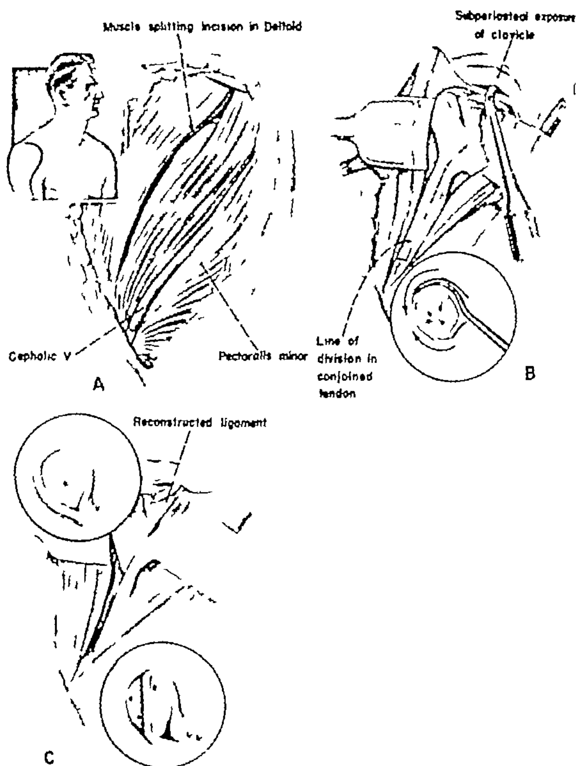


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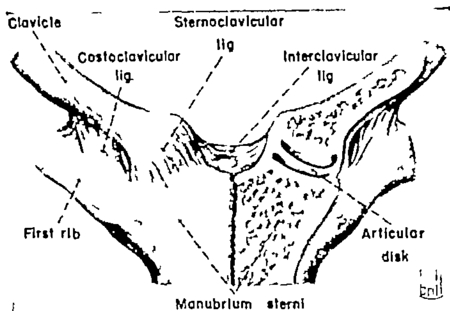


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TREATMENT OF OLD DISLOCATIONS As in all chronic lesions about the shoulder joint, full evaluation of motion or pain present in relation to the patient and his needs is essential Resection of the end of the clavicle is the method of choice in older patients, those patients not requiring a powerful shoulder and in cases where pain is the

reason for therapy Reconstruction of the coracoclavicular ligament with either fascia lata or the conjoined tendon is preferred in young individuals or those requiring a strong shoulder

Dislocations of the Sternoclavicular Joint The integrity of the sternoclavicular joint is maintained by the costoclavicular interclavicular and sternoclavicular ligaments (Fig 30) Usually the latter is involved in a dislocation. Trauma most frequently is that of a downward force on the tip of the shoulder whereby the first rib levers the proximal end of the clavicle upward and backward. Extreme force may cause impingement on the structures in the neck by the proximal end of the clavicle

Although rare the diagnosis is easily made by the deformity variable loss of motion of the shoulder and pain and tenderness on palpation

TREATMENT Although easily reduced by elevating the shoulders upward, outward and backward with pressure on the proximal end of the clavicle maintenance of this reduction is difficult. This best is accomplished by means of a plaster of paris posterior figure of eight bandage using 10 cm (4 inch) bandages (Fig 31) The anterior tip of the shoulders must be protected with felt and the axillas with wads of cotton. While the plaster is drying the patient lies in a recumbent position having a folded sheet between the scapulae and at the same time downward pressure is exerted on the shoulder tips. Care must be taken to avoid vascular embarrassment due to pressure in the axilla This immobilization is worn for a six weeks period

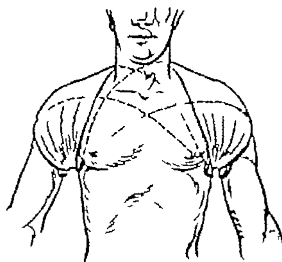


FIG. 31 Posterior figure-of-eight plaster-of-paris bandage 10 cm. (4 inches) wide holding shoulders upward and backward. Note cotton wadding in each axilla.

Lateral traction on the arm may also be used if the above method fails a sandbag is placed over the sternoclavicular joint at the same time This is maintained for a three weeks period following which the plaster-of-paris figure of-eight is applied for a three to five week period During this latter period, the patient is ambulatory

Most frequently chronic dislocations must be treated by operative procedures

if treatment is indicated Speed and Bankhart have both devised methods which are very satisfactory One should appreciate before attempting either procedure that the area is prone to profuse bleeding and complications pertaining to the surrounding structures

Speed's reconstruction of the sternoclavicular joint is by the use of two strips of fascia lata (Fig 32) The

Bankhart's technic is that of making two drill holes in the proximal end of the clavicle and also in the sternum The meniscus is removed as it is in the above procedure if damaged. Fascia lata strips are then passed through the drill holes in a mattress suture manner and anchored firmly on themselves by means of a knot and sutures

A much less complicated procedure

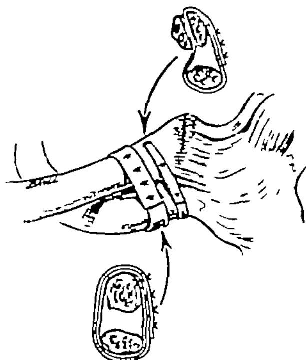


Fig. 32. Reconstruction of sternoclavicular ligaments. Operation of Speed and Smith.

proximal end of the clavicle as well as the proximal 5 cm (2 inches) of the first rib are stripped subperiosteally The two strips of fascia are then placed subperiosteally around both the clavicle (one through the clavicle) and the first rib The pectoralis major muscle fibers are reflected downward to expose the area The two strips of fascia lata are then sutured onto themselves. Postoperatively they are immobilized in a Velpeau dressing for a three to four week period, then started on full range of motion exercises

is that of resection of the mesial 3 7 cm. (1½ inches) of the clavicle This is done subperiosteally using the periosteal flap to cover the raw surfaces of bone This last procedure has the advantage of being compatible with good painless function and, at the same time decreasing the period of recovery due to immobilization.

ACUTE INJURIES OF THE BICEPS TENDON

Acute Bicipital Tenosynovitis

Introduction Acute bicipital teno-

synovitis is an inflammatory process involving the tendon and tendon sheath of the long head of the biceps brachii muscle. This entity is the commonest etiologic factor responsible for the symptom complex comprising a frozen shoulder.

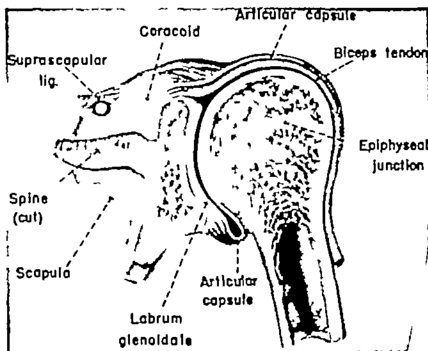


FIG. 33. Frontal section of the right shoulder joint, posterior view. Observe the redundancy of the capsule on the inferior aspect of the neck of the humerus. The fibrous capsule is lined with synovial membrane which is prolonged around the tendon of the long head of the biceps muscle as far as the surgical neck of the humerus, providing a synovial cover for the osteofibrous bicipital tunnel. It then ends as a blind sac and is reflected upon the tendon. (Redrawn from S. W. Spalteholz: Hand Atlas of Human Anatomy. Philadelphia, Lippincott.)

The tendon of the long head of the biceps muscle has its origin on the supraglenoid tuberosity and frequently also from the superior glenohumeral ligament (Fig. 33). It courses over the anterior aspect of the humeral head within the fibrous capsule of the joint. The inner surface of the capsule is lined with a synovial membrane, the synovialis. Laterally the tendon lies within the intertubercular groove which courses between the two tuberosities. The tendon is held within the bicipital groove by the transverse humeral ligament which transversely courses the groove just distal to the tuberosities. A prolongation of the capsule extends slightly distal to this ligament (Fig. 34). The principle of the gliding mechanism of the biceps tendon is that the tendon remains fixed in the groove during motion while the head of the humerus glides up and down on the tendon. In *particular motions such as in internal* rotation the lesser tuberosity acts as a trochlea to the tendon which of course predisposes the tendon to early degenerative changes. In external rotation, the tendon lies in the floor of the groove and across the center of the humeral

head so that it acts as a depressor of the head as well as an abductor of the humerus

General Bicipital tenosynovitis may or may not be initiated by trauma In those cases in which trauma is an etiologic factor men are afflicted more often than women In those cases without trauma and insidious in onset women are more often afflicted than men Investigative work has shown that frozen shoulders do not occur in patients under thirty years of age but rather from the fourth decennium upward And in cases in which a frozen shoulder results most frequently the patient is in a debilitated state due to pulmonary cardiovascular and gastrointestinal diseases a close relationship exists between their general physical status and the high incidence of a frozen shoulder

Pathogenesis of a Frozen Shoulder in Relation to Bicipital Tenosyno-

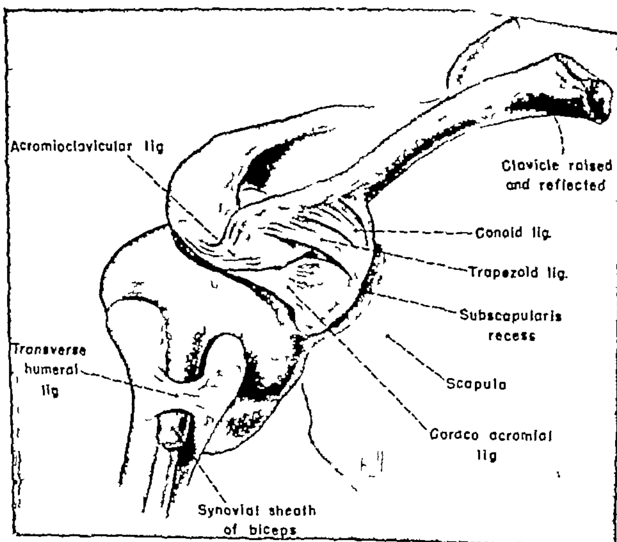


Fig. 34 Extensions of the synovial capsule of the scapulohumeral joint and the coracoclavicular ligaments. Note the prolongation of the synovialis anteriorly under the coracoid process, forming the subscapularis recess and the second prolongation lining the bicipital groove It ends as a blind pouch and then is reflected over the biceps tendon.

vitis One must first understand the pathogenesis involved in a frozen shoulder before the importance of bicipital tenosynovitis as an etiologic factor can be appreciated. Muscular inactivity is the basic causative agent responsible for a frozen shoulder Any cause restricting scapulohumeral motion produces muscular inactivity This leads to diminished muscle tone and subsequent muscular atrophy Associated with these changes there is lymphatic and venous stasis as well as slowing down of the circulation. This leads to a low grade inflammatory process (Fig 34) in the involved soft tissues of the shoulder joint which ultimately either resolves or leads to loss of elasticity shortening and fibrosis of these tissues This becomes a vicious cycle in which shoulder motion is further restricted The shoulder joint is unique in that its anatomy renders it susceptible to changes which produce stiffness, but frozen shoulders only result when degenerative changes are present in the tissues involved It is thus that frozen shoulders are seen rarely before the fourth decade It is understandable that any damage to the synovialis, musculotendinous cuff or other soft tissues of the shoulder joint will initiate the processes constituting a bicipital tenosynovitis and ultimately a frozen shoulder As was noted in the discussion of ruptures of the musculotendinous cuff and in dislocations of the shoulder joint the biceps tendon is very prone to secondary involvement in these lesions



Fig. 35 (Left) Specimen obtained from a cadaver in which there is evidence of a depressed fracture of the anatomic neck and the head of the humerus. The upper portion of the intertubercular sulcus has been completely obliterated and is filled in with numerous bony excrescences. The inferior surface of the corresponding biceps tendon exhibited advanced degenerative changes. (Right) Specimen obtained from a cadaver which had sustained a fracture through the surgical neck. Note the complete obliteration of the bicipital groove and marked irregular new bone formation. In this specimen the extracapsular portion of the biceps tendon was found attached to this bony mass. The intracapsular portion was absent.

Bicipital Tenosynovitis Associated

with Trauma GENERAL The trauma involved may be minor such as a fall on the point of the shoulder or strenuous exercises Fractures about or involving the head and neck of the humerus or dislocations of the glenohumeral joint associated with fractures constitutes the severe type of trauma

PATHOLOGY IN MINOR TRAUMATA The early changes are those of an acute inflammatory process. The tendon is markedly injected and edematous which constricts the tendon within the sheath There may be some tearing of the superior subscapularis tendon fibers from their insertion as well as hemorrhagic areas below the synovialis lining the groove This process progresses whereby adhesions which vary from early filmy structures to late fibrous structures are formed between the tendon and the sheath The tendon and sheath may be attached to the transverse humeral ligament or to the floor or side of the groove This process may extend intracapsularly as far as the coracohumeral ligament. Only when the tendon and the tendon sheath are adherent to the inner surface of the capsule is there a mechanical block of motion Such obliteration of the normal gliding mechanism does not prevent motion Frequently well-formed intertubercular ridges are found which diminish and distort the depth of the groove Changes consistent with a frozen shoulder are not found in those individuals under thirty years of age Beginning at the fourth decade and progressively into the fifth and sixth decades, one finds more severe degenerative changes *consistent* with normal wear and tear Degenerative alterations must be present in the soft tissues before bicipital tenosynovitis can develop

PATHOLOGY OF SEVERE TRAUMATA The pathology in these lesions is a combination of an inflammatory process plus any changes in the osseous portions of the groove The entire tendon may be obliterated by dense adhesions in the groove The tendon may be frayed to just a thin strand of fibrous tissue The groove is usually shallower and narrowed with osseous spurs on the sides or floor Fractures through the tuberosities may have stimulated bony growth to obliterate portions of the groove (Fig 35) The tendon may be adherent to the sheath groove and inner surface of the capsule as far intracapsularly as the coracohumeral ligament. The tendon may be anchored at the level of the transverse humeral ligament either by fibrous or bony union Freedom of motion is attained when the tendon is released from the inner surface of the capsule

CLINICAL FEATURES OF BICIPITAL TENOSYNOVITIS DUE TO TRAUMA Pain in the anterolateral aspect of the shoulder is the outstanding symptom There is frequent radiation of the pain to the insertion of the deltoid muscle and to the belly of the biceps muscle If severe, it may radiate into the posterior cervical and scapular regions The pain is more severe at night and particularly if pressure is applied to the area. The most constant finding is that of *exquisite* tenderness when the biceps tendon is rolled within the bicipital groove by the examiner's thumb Motion is nearly always restricted but never completely lost. Abduction, external rotation, and backward flexion with external rotation are the most painful motions although there is always an arc of painless motion present. Varying degrees of muscle spasm are present. These clinical features vary with the type of trauma The foregoing is more applicable to minor

trauma the same picture is seen in severe trauma though masked by fractures, dislocations etc.

X ray examination in cases of minor trauma is of little or no value In severe trauma roentgenographic evidence of fracture or any lesion of the upper end of the humerus which disrupts the normal configuration of the bicipital groove may initiate a bicipital tenosynovitis



FIG. 36 Schematic drawing showing a supratubercular ridge which may facilitate displacement of biceps tendon out of the intertubercular sulcus.

The clinical course varies with the age of the individual and the extent of the injury In the younger age group the acute phase subsides gradually with rest and graduated exercises within a range of painless motion Only occasionally is the acute phase protracted The acute phase in the older age groups (over forty years of age) may or may not recede If it does not, there is gradual decrease of motion in the glenohumeral joint until there is a fibrous ankylosis or a frozen shoulder Pain either may disappear completely or it may be intractable

The clinical course of events is dependent upon the tendon-tendon sheath gliding mechanism It is either restored by gradual dissolution of the binding adhesions or the tendon attains a fibrous or bony anchorage in the bicipital groove

Bicipital Tenosynovitis Not Associated with Trauma Bicipital tenosynovitis is seen as frequently in patients with no history of trauma as those with a history of trauma The onset is insidious usually and presents the same type of clinical picture and symptoms. Again there are essentially two groups into which they might be classified

The younger age group presents simi-

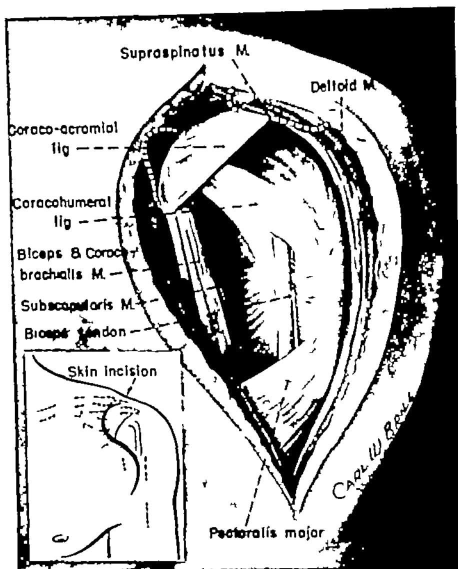


FIG. 37 Exposure of anterior aspect of the shoulder by the S-shaped skin incision of Hitchcock and Bechtol as shown in insert. The deeper structures are exposed by developing the deltopectoral cleft and retracting the deltoid muscle laterally and the pectoralis major muscle mesially Approximately 1 cm. (2/5 inch) of the medial border of the deltoid muscle together with the cephalic vein are displaced medially with the pectoralis major muscle.

lar clinical findings At operation consistent findings of irregular configurations of the bicipital sulcus suggest a basic etiologic factor responsible for bicipital tenosynovitis in these individuals (Fig 36) though one must always consider abnormal wear and tear dependent upon the patient s occupation.

The older age group presents the same type of picture as seen in the younger age group except that they are prone to develop a frozen shoulder This is particularly true in those patients who are in a general state of debilitation This becomes more pronounced as the age of the patient is more advanced.

Treatment. CONSERVATIVE Bicipital tenosynovitis should be treated conserva-

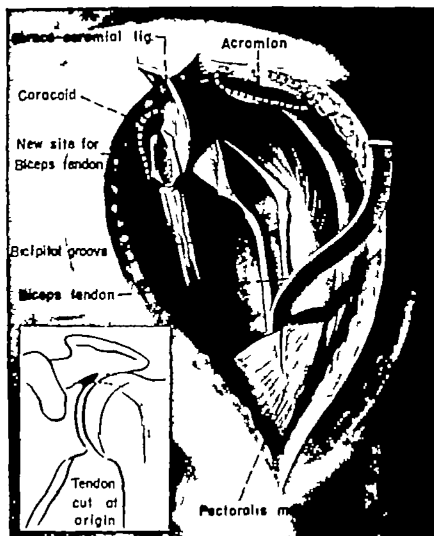


FIG. 38 The intertubercular groove is opened by a longitudinal incision through the transverse humeral ligament the incision is extended through the fibers of the coraco-humeral ligament in the interval between the subscapularis and the supraspinatus muscles next the biceps tendon is severed at the superior glenoid brim and withdrawn from the joint cavity The coracoacromial ligament is divided close to its insertion into the acromion also the tendinous fibers of the insertion of the pectoralis major are divided for 1 to 3 centimeters (4/5 to 1 1/5 inches) A bony trough is cut out of the coracoid process.

tively in the early stages regardless of the etiological factors Rest to the part by means of a sling along with restriction of motion within painless arcs is usually sufficient to terminate the syndrome Graduated pendulum exercises within the tolerance of pain and fatigue are instituted With the regression of the symptoms motion is correspondingly increased

SURGICAL Surgical intervention is justified in (1) patients not responding to conservative therapy (2) in those patients experiencing repeated recurrences of the symptoms (3) in the following types of fractures (a) cases with

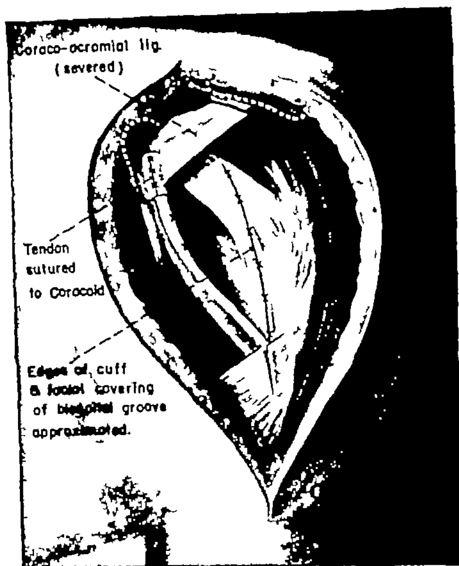


FIG. 39 The biceps tendon is sutured in the trough in the coracoid process and to the tendon of the short head of the biceps brachii muscle; the incision in the coracohumeral and transverse humeral ligaments is closed by interrupted sutures.

fracture dislocations of the humeral head in which the biceps tendon has been dislocated from the upper portion of the groove (b) cases of fractures of the greater tuberosity with retraction of the fragments under the acromion in which the fracture line traverses the bicipital sulcus and (c) cases of depressed fractures of the greater tuberosity in which the biceps tendon is compressed by displaced fragments of bone (4) in cases of supraspinatus tears in which pain and limitation of motion persists and (5) in those cases in which a frozen shoulder is inevitable The procedure of choice is transplantation of the biceps tendon to the coracoid process.

An S-shaped skin incision over the anterior portion of the deltoid muscle is used (Fig 37) The fibers are divided longitudinally exposing the musculotendinous cuff and the subacromial

bursa which are carefully inspected. The transverse humeral ligament and the capsule are then incised longitudinally as well as a portion of the coracohumeral ligament This exposes both the intra and extracapsular portions of the biceps tendon The biceps tendon is then severed as close to its origin as possible The coracoacromial ligament is then severed at its insertion on the acromion It has been found that this permits more freedom of abduction A vertical incision 12 mm (½ inch) long is then made through the conjoined tendon over the tip of the coracoid process (Fig 38) A trough is then made subperiosteally in this area to which the freed end of the biceps tendon is sutured subperiosteally The biceps tendon is then sutured distally for 5 cm (2 inches) to the fibers of the coracobrachialis and the short head of the biceps The fibrous capsule and transverse humeral ligaments are approximated with silk sutures (Fig 39) The wound is then closed in layers No manipulation is done

Postoperatively the shoulder is immobilized in a sling for five days during which time pendulum exercises are prescribed hourly Motion is kept within the tolerance of the patient Motion is restored in three to four months.

Traumatic Subluxation or Dislocation of the Tendon of the Long Head of the Biceps Brachii Muscle

The maintenance of the biceps tendon in the bicipital groove is dependent on several factors the depth and width of the groove the tuberosities, the transverse humeral ligament and tonicity of the tendon itself If any one of these factors is lacking the possibility or probability of a subluxation or dislocation is enhanced When the arm is abducted and externally rotated, the tendon impinges on the lesser tuberosity as it would a trochlea The presence of a supratubercular ridge in the intertubercular sulcus elevates the tendon so that it slips over the tuberosity and subluxates in extreme motion or stress Any degenerative changes such as wearing off of the tuberosities, decreasing the depth of the sulcus will predispose to the same type of mechanism This mechanism is further enhanced by the gradual tearing and elongation of the expansion between the insertion of the pectoralis major muscle and the insertion of the subscapularis muscle from the anterior lip of the sulcus

Clinical Features. The onset of severe pain in the anterolateral aspect of the shoulder following acute stress is a pertinent clinical feature in acute traumatic subluxations of the bicipital tendons Limitation of motion is present particularly in abduction and external rotation A snap is frequently heard as the tendon either dislocates or reduces itself over the lesser tuberosity Most frequently the lesion takes on a chronic nature after the initial lesion Frequently the patient voluntarily subluxates the tendon It becomes apparent that if repeated subluxations occur a chronic inflammatory process of the tendon ensues These changes tend to establish a chronic syndrome of a bicipital tenosynovitis

Treatment Surgical treatment is the one of choice The same type of procedure is used as for bicipital tenosynovitis (Fig. 39) The surgical procedure described obliterates the tendon tendon sheath gliding mechanism and hence precludes the development of bicipital tenosynovitis. One may suture the tendon into the bicipital groove rather than

onto the coracoid process if he wishes Postoperatively the management is the same

RUPTURES OF THE BICEPS TENDON

The biceps tendon is particularly prone to rupture because of the normally age group only infrequently does one occur in a younger person except with a history of undue violence or exertion Spontaneous ruptures may occur in those individuals in whom the tendon is frayed to the point where *normal* contraction will cause severance of the

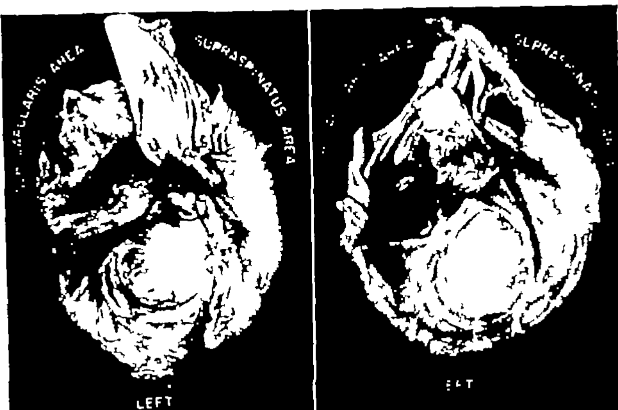


FIG. 40 Marked hypertrophy of all the intracapsular structures except the labrum in the region of the comma's head also advanced fraying, shredding, and hypertrophy of the biceps tendon. Note the advanced degenerative lesions in the musculotendinous cuff of this specimen.

early degenerative changes present within the tendon and on the structures with which the tendon comes in contact. Starting at about the fourth decade, degenerative lesions associated with the biceps tendon are noted with increasing frequency (Fig 40) Thus the tendon is normally frayed and shredded to some extent and when excess stress or contraction is sustained, a rupture occurs

Most ruptures are seen in the middle tendon Ruptures may be either partial or complete

Site of the Rupture The weakest portion of the tendon is the segment lying in the intertubercular sulcus just distal to its point of exit from the joint cavity Gilcreest reported thirty four of seventy three operative cases to be intracapsular ruptures In nine of the seventy-three cases, the rupture was at the point of origin on the supraglenoid

tuberosity In the rest of his cases twenty were at the upper musculotendinous junction and two were at the lower musculotendinous junction (Fig 41) He reported only two cases of partial rupture



FIG. 41 Rupture of biceps muscle at the lower musculotendinous junction. When the biceps muscle is contracted the muscle mass is displaced proximally to the upper part of the arm. Note the flattened area in the lower part of the arm below the bulge made by the contracted muscle.

placed muscle mass away from the site of rupture. Complete and incomplete ruptures are determined by the degree of retraction. If the rupture is through an avascular portion of the tendon, no hematoma or ecchymosis will be noted,

Clinical Features The clinical picture varies considerably dependent upon the cause for rupture Rupture of the biceps which shows little or no degenerative changes is an acute episode of severe lancinating pain in the shoulder and upper arm following severe contraction of the muscle Frequently the patient hears a click or snap when it ruptures Dependent on the location of the rupture there will be noted a dis- if through the vascular portions, this will be a distinguishable feature

In ruptures of degenerated tendons no pain may be found or no specific incidence of onset weakness may have been gradual (Fig 42) Usually only slight impairment of function is noted in comparison to the acute traumatic ruptures in which impairment of function is usually a cardinal feature

Treatment Conservative treatment

is indicated in latent cases particularly in elderly individuals with decreasing need for good function Usually there is little difference in function following rupture

Surgical repair is indicated in acute traumatic ruptures in which there is marked impairment of function Dependent upon the site of ruptures, the type nous junctions are approximated in an end-to-end manner if of good healthy tissue and can be done with minimal tension

Postoperatively the arm is immobilized in a plaster swathe (Fig. 21) for a three week period following which physical therapy is directed toward restoration of shoulder and elbow func

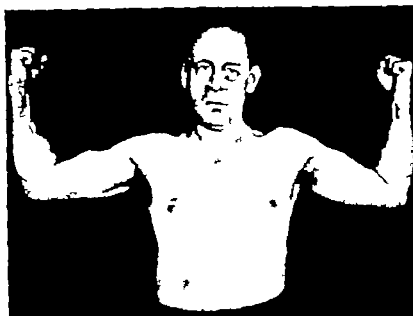


FIG. 42. Rupture of the biceps causing no symptoms other than minimal weakness of the arm. In view of the absence of pain and little or no impairment of function, surgical intervention is not justifiable.

of repair of necessity varies If the rupture is in the intracapsular portion of the tendon transplantation of the distal end of the tendon to the coracoid process gives good results (Fig 39) or it may be sutured to the short head of the biceps The tendon may also be sutured to the intertubercular sulcus

Ruptures through the belly should be approximated by deep interrupted mattress sutures of silk or cotton. Fascial transplants should be used as reinforcement if necessary

Ruptures through the musculotendi-

tion. Acute flexion of the elbow is not permitted for six weeks and contraction of the biceps is not *permitted* for ten weeks

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FIG. 41. Rupture of biceps muscle at the lower musculotendinous junction. When the biceps muscle is contracted, the muscle mass is displaced proximally to the upper part of the arm. Note the flattened area in the lower part of the arm below the bulge made by the contracted muscle.

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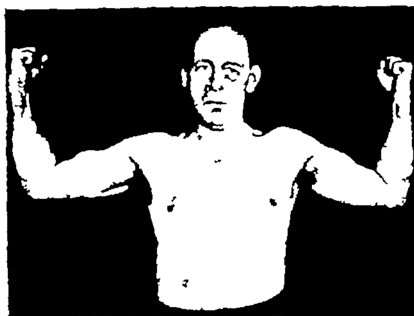


Fig. 42. Rupture of the biceps causing no symptoms other than minimal weakness of the arm. In view of the absence of pain and little or no impairment of function, surgical intervention is not justifiable.

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38

Acute Nonfracture Injuries of the Knee and Ankle

NONFRACTURE INJURIES OF THE KNEE JOINT

THE writer would like to preface this section by referring to "the largest and most vulnerable joint in the body " but unfortunately this has been done so often it has become trite Though not original, it is still very true and injuries to the knee joint without fracture are extremely common and often very disabling. Description of these injuries requires some consideration of the ligaments of the knee joint, the menisci, the synovia and the bursae about the joint.

As regards the ligaments and menisci present day concepts of anatomy and function are based largely on the writings of Brantigan and Voshell[1] and Last.[2] Complete details of their studies can be obtained only by referring to their publications Certain fundamental facts, however will be presented

The Ligaments The tibial collateral ligament is a dense fibrous band, which runs from the medial femoral epicondyle down to a point on the medial surface of the tibia about 3 1 cm (1¼ inch) below the articular margin. Brantigan and Voshell describe a posterior *extension attaching* just below the articular margin, on the posteromedial aspect. This entire structure is tense in extension As the knee flexes the posterior expansion relaxes slightly while the remainder stays taut.

The fibular collateral ligament is also a dense fibrous band, running from the lateral femoral epicondyle down to the upper portion of the fibular head It is taut in extension, but relaxes in flexion

The *anterior cruciate ligament* runs from the anterior aspect of the tibial spine upward, backward, and laterally to the medial surface of the lateral femoral condyle It is under greatest tension in full extension but some tension is sustained throughout the complete range of flexion

The posterior cruciate ligament attaches inferiorly in a depression just posterior to the tibial spine, and runs upward, forward, and medially to the lateral surface of the medial femoral condyle. Like the anterior cruciate, it is taut throughout the *entire range of motion* of the joint, but is under its greatest tension when the knee is flexed.

The ligaments of Humphrey and Wrisberg are of interest anatomically but have little surgical importance

The quadriceps tendon is the most central portion of the *fibrous* envelope

of the knee joint. It attaches to the superior pole of the patella then expands laterally and medially to blend into the capsule

The patellar tendon is the inferior central portion of the fibrous envelope, extending down from the inferior pole of the patella to the tibial tubercle It is a much more discrete and clearly demarcated structure than the quadriceps tendon

Motion of the Knee Joint The knee is commonly described as a hinge joint, and motion at this joint is usually thought of as being limited to flexion and extension It should be remembered that a very important, but somewhat less obvious component of the knee action is a slight medial rotation of the tibia on the femur as the knee is flexed and a slight lateral rotation of the tibia as the knee is brought into full extension.

Lateral motion is impossible in a fully extended knee, but when flexion occurs, relaxation of the fibular collateral ligament permits a slight degree of adduction Rotary movements are also possible in flexion but cannot be done in extension

Injuries of the Ligaments

Tibial Collateral Sprains The general thought as to the mechanism of the injury is that it requires an abduction force with the knee extended Smillie[3] takes exception to this He points out the fact that the extended knee is very stable and that sprains commonly result from a rotary force applied to the slightly flexed knee Strains can affect any part of the ligament, but are commonest at the femoral epicondylar attachment. In extent they may vary from rupture of a few fibers to avulsion of a superficial part of the epicondylar cortex

The clinical findings vary with the extent of the pathology Localized pain and tenderness may be accompanied by localized swelling synovial effusion, and at times localized subcutaneous extravasation of blood

Roentgen examination will show increased intra-articular fluid or cortical avulsion if these are present, but otherwise will be unrevealing

Treatment will have to be varied according to the severity of the injury In a very mild injury procaine infiltration into the affected area and strapping of the joint will suffice If the tear is more extensive bed rest for five to seven days may be required. Local cold applications help to limit swelling and lessen pain within the first day or two. An effusion into the joint should be aspirated, and aspiration must be repeated if necessary A dressing which applies moderate compression should be applied. Quadriceps exercises should be instituted as soon as possible The use of a 6 mm (¼ inch) lift on the inner border of the heel serves only to throw the subtalar joint out of alignment, and this increases the strain on the tibial collateral ligament. This practice is mentioned only for the purpose of condemning it.

A possible late complication of this injury is the occurrence of calcification of a portion of the ligament This condition, known as Pellegrini-Steida s disease usually is found in the region of the femoral attachment. Such calcification may be responsible for prolonged pain, and interference with flexion The original calcific deposit eventually becomes true osseous tissue It is best treated by judicious neglect Too vigorous attempts to improve knee motion will probably aggravate the condition Attempts to remove the deposit surgically will be followed by recurrence with probably more extensive involvement Smillie[3] however feels

that in a few selected cases after the process has become static the bony mass may be excised with improvement of function even though minor recurrence of bone formation may be observed

RUPTURES The mechanism of rupture of the tibial collateral ligament is usually the application of a heavy force against the lateral aspect of the extended knee Rupture may be complete or incomplete It may occur at the bony attachments or across the main body of the ligament. Complete rupture without associated injuries to the other ligaments or to the medial miniscus is uncommon Fractures of the tibial condyles are also commonly associated

Clinically the pain, tenderness, and swelling localized over the medial aspect of the knee are much more marked than with a simple sprain The swelling is usually diffuse and intra articular effusion will be observed only if the capsule has not been torn Subcutaneous extravasation of blood is common Disability is usually severe

Roentgen examination may be completely negative at first If however it is done under anesthesia, lateral rocking of the joint can be demonstrated when the tear is complete Associated condylar fractures are usually easily demonstrated, but if there is no displacement, such fractures might be overlooked

Treatment should be carried out in accordance with the extent of the pathology An incomplete tear should be treated conservatively Aspiration and compression dressings may be necessary As soon as the swelling subsides the knee should be immobilized by means of a plaster cylinder extending from just above the ankle to the groin Weight-bearing may be started when the knee has been immobilized Quadriceps exercises should be instituted as soon as possible The plaster immobilization should be removed after six to eight weeks and physical therapeutic measures should then be instituted

Complete tears should be treated in the light of the associated injuries A complete tear without complicating fracture should be repaired immediately The manner of repair will have to be determined by the location of the tear If it has torn at or near the bony attachment it should be reattached to bone This can be done by means of a metal screw if a piece of cortex has been avulsed or by means of through and through suture in the bone itself The unwary surgeon who finds himself confronted by a tear across the midportion of the ligament will be hard put to it to make both ends meet. The extensive fraying of the torn ends makes apposition difficult if not impossible and the use of fascia lata or a tendon graft of small caliber may be required to bridge the gap Associated soft tissue injuries should be repaired at the same time

If there is a coincident fracture treatment of the injury should be directed at the fracture and immediate repair of the ligament should not be done. No hard and fast rule can be set down as to the late repair of ruptures It will often be found that there is little residual instability and very little resultant disability In such cases development of good quadriceps power will overcome the handicap If instability is marked, with consequent disability repair will be necessary

Fibular Collateral Ligament This structure is injured much less frequently than its opposite number It is somewhat more lax, by nature, than the tibial collateral, hence the force required to injure it must of necessity be greater For this reason, one naturally might expect that associated injuries will be more fre-

quently found than in trauma to the medial side of the joint Other than this the producing forces the clinical and roentgen findings and the principles of treatment are in general very similar

The Cruciate Ligaments The protected position of these structures in the center of the joint is somewhat neutralized by the fact that, as shown by Brantigan and Voshell [11] they are both under some degree of tension throughout the entire range of joint motion Isolated injury of the posterior cruciate is somewhat rare Usually it is found as part of an extensive condition involving other joint structures Isolated injury of the anterior cruciate is somewhat commoner It may occur as the result of a severe rotation force, or as a result of a force which drives the fixed tibia backward on the femur with the knee in flexion Any portion of the ligament may be torn but most commonly the central portion is found to be involved. Trauma involving the lower portion may result in avulsion of the tibial spine Tears may be complete or incomplete A consideration of the amount of force which would be required completely to disrupt either or both of these ligaments makes it easy to understand why they are most commonly found as merely a component part of a complicated knee joint injury

If only the anterior cruciate is torn, the immediate clinical sequelae will be pain and probably intra articular swelling due to hemorrhage or synovial effusion Instability may not be appreciated immediately because of the splinting due to pain. Classically the tibia can be displaced *forward on* the femur but it is very important to remember that this can be determined best only when the knee is held at a right angle.

In the presence of an isolated posterior cruciate tear the clinical findings will be similar except that the instability will be posteriorward. Smillie's caution that both knees be compared is very important He points out that what might appear to be increased anterior mobility may in reality be simply the restoration of a posterior luxation to its normal position

Roentgen examination will be negative unless there has been an avulsion of the tibial spine

Treatment of a simple tear should be confined to conservative measures unless definite immediate diagnosis can be made In this instance surgical repair might be of value If the tibial spine has been avulsed, it should be reattached by means of a circumscribing suture the ends of which are brought down obliquely through parallel drill holes to the anterior surface in the region of the tibial tubercle where they are tied Late recognition of this entity indicates the use of conservative therapy As in all other knee injuries, one of the most important features of treatment is rigid attention to restoration of good quadriceps function As to the value of surgical repair or reconstruction of the cruciate when late diagnosis is made, the usual differences of opinion exist. Several operative procedures have been devised, but the preponderance of opinion is that none of them is any good

The Menisci

Anatomically the medial meniscus is a half moon, attached anteriorly to the intercondylar depression of the tibia just anterior to the tibial spine and posteriorly to the intercondylar region between the tibial spine and the attachment of the posterior cruciate ligament

Earlier writings describe the presence of coronary ligaments, attaching the periphery of the meniscus to the periphery of the tibial condyle These are not described in later articles but there is a definite attachment present It is firmly attached to the posterior portion of the tibial collateral ligament "There is no strong fibrous attachment between the tibial collateral ligament and the medial meniscus"[1] If it is not attached the writer wonders what it is that always makes it so difficult for him to free the entire periphery The peripheral thickness and the width of the medial meniscus are variable factors More commonly the interior portion is narrower than the posterior but this rule is by no means universal

The lateral meniscus is more nearly circular than its mate It is wider and is usually thicker at the periphery Its anterior attachment is just anterior to the tibial spine, where it finds an attachment to the anterior cruciate Posteriorly its attachment is found between the spines and extends upward by means of two string fibrous bands to the medial femoral condyle The band anterior to the posterior cruciate ligament is called the ligament of Humphrey That which is posterior to the posterior cruciate is the ligament of Wrisberg The lateral meniscus like the medial, has a peripheral attachment to the periphery of the condyle of the tibia.

The configuration, location, and attachments of the menisci are such that a tear of either of them requires a combination of rotary and flexion forces The writer in examining industrial accident cases is frequently confronted with the diagnosis of "medial or lateral meniscus tear" in individuals who have sustained direct blows on the fully extended or half flexed knee As a rule the blow described is one which would have to be considered relatively minor Such an accident cannot be considered a valid producing cause of meniscus tear A direct blow on the stationary knee in order to cause a tear of either of the menisci would have to be sufficiently severe to cause other damage to the joint.

The rigid concept that a tear of the medial meniscus is produced only by a flexion abduction and external rotation force and is always longitudinal in the body of the cartilage is a fallacious textbook heritage In addition to the classic bucket handle tear which presents the so-called typical picture either cartilage may be torn loose at either end, or around the periphery Transverse tears are probably as common as longitudinal tears, and may occur at any portion of either edge of the medial meniscus, but are most often present in the mid-third of the inner edge At times, congenital predisposing factors, such as variations in shape and the rigidity of the attachments may account for some of the less common forms of pathology The influence of such congenital predispositions is attested by the occurrence of medial meniscus tears following relatively minor trauma first in one knee then after some lapse of time, in the other Where developmental predisposition exists particularly laxity of the attachments continued maintenance of a squatting position with frequent changes in the degree of flexion can cause the meniscus to be "pumped" into the space between the femoral and tibial condyles, with resultant damage when the erect posture is resumed.

The clinical manifestations of meniscus injury particularly tear of the medial meniscus have been described as

a classic triad, namely locking pain and swelling Such findings when present, suggest very strongly the presence of a longitudinal tear through the body of the cartilage Similar phenomena, however can be observed when a loose osteocartilaginous body becomes impinged between the femoral and tibial condyles Moreover since the extent and location of the injury are such variable factors it is natural to expect variations in the symptomatology The *one most nearly constant complaint is* pain This may be definitely localized or may be described vaguely as being "inside the joint." Joint effusion usually follows tears of any magnitude but will be absent if the tear is minor in degree Locking, in the true sense of the word, is relatively uncommon It will occur only when the tear is of such a nature as to permit a portion of the cartilage to become caught within the space between the condyles of the femur and the tibia. Close questioning of many patients who complain of "locking" will reveal that frequently they use this term to describe a transient, incomplete stiffness of the joint. This type of "locking" may occur in any arthritic joint after resting in a fixed position for any length of time One of the common findings in cases of long standing is quadriceps atrophy which itself tends to favor the development of further pathology within the joint It will frequently be noted that extension of the knee is just less than complete. If the knee is held elevated from the examining table with the heel in one hand while with the other hand an attempt is made to force extension, pain within the joint can be considered to indicate intra articular pathology If this maneuver produces pain behind the knee it is more probably due to hamstring spasm resulting from arthritis or possibly extra articular disease

McMurray[4] has devised a test which is designed to show the presence of posterior meniscus tears Rotation of the fully flexed knee will cause a click, according to him. It is theoretically possible to distinguish between meniscus injury and collateral ligament injury by means of the Apley[3] maneuver This is performed with the patient in the prone position. The examiner grasps one foot *in either hand, externally rotates then* flexes both knees as far as possible He then rotates internally and extends the knees together again This preliminary test is then followed by examining each knee separately With the patient still lying prone the knee is flexed to a right angle and simple external rotation is done The patient's thigh is then fixed by the examiner's knee and strong external rotation of the leg is *done at the same time that a strong* distracting force is applied. These two tests are designed to indicate the presence or absence of rotation sprain A third test is then performed, with the position of the patient unchanged The examiner applies his whole body weight so as to compress the tibia against the femur and the leg is then externally rotated This test, if it elicits complaints of increased localized pain indicates the presence of medial meniscus injury

The patient frequently complains of "giving way" of the knee This complaint is a result of quadriceps weakness which may be due to any one of a number of causes, and is not diagnostic of meniscus injury

Roentgen examination is of little help in establishing a diagnosis of meniscus injury Its chief value is a negative one By means of radiography other pathologic conditions can be ruled out No

reliance can be placed on the finding of a narrowing of the joint space on one side Pneumarthrography has its enthusiastic proponents but in general difficulties of technic and interpretation place sharp and narrow limitations on its applicability

Unless and until more definite criteria can be established it is the writer s fear that for years to come we will continue to see frequent examples of operations performed for suspected medial meniscus tears in which the postoperative diagnosis will read "hypertrophied infrapatellar fat pad " or "loose cartilage "

The management of an acute meniscus injury must be determined by a realization of the pathology present It must be borne in mind that healing can occur in only the most minor tears there is usually some associated pathology present a torn cartilage which is allowed to remain displaced has the same effect as any loose body and its continued presence results in further damage to the articular surfaces of the femoral and tibial condyles If these facts are given their proper value it will be easy to understand that meniscus injuries should have the same right to immediate treatment that is conceded to fractures

Weight bearing should be forbidden immediately If there is displacement with true locking, reduction should be done as early as possible, preferably under anesthesia. Following reduction, effusion should be aspirated and compression dressings applied It must be emphasized again that quadriceps exercises should be started as soon as possible If reduction is complete a cylinder cast may be applied as soon as the effusion and swelling have subsided, and the knee should be kept immobilized for three weeks During this time the patient may be permitted to bear weight Such conservative treatment, however should be limited to initial cartilage injuries At the first sign of recurrence the cartilage should be removed If closed reduction cannot be accomplished *completely so that full* extension can be obtained with ease conservative treatment can lead only to further trouble In this event, surgical removal of the cartilage is indicated These precepts are somewhat at variance with those of Smillie whose opinion is that every cartilage should be removed as soon as there is convincing evidence that it is torn.

Patients whose knee injuries are such that an accurate diagnosis of meniscus injury cannot be made should be treated conservatively Such treatment may require the use of bed rest, aspiration of effusion, compression dressings the use of adhesive traction and possibly rigid immobilization for a period of three weeks Again, it is to be remembered that quadriceps exercises should be started immediately

The technic of operative removal cannot be treated in full, but certain fundamentals should be mentioned. The operative trauma should be minimal The operator should use the smallest incision through which he can adequately expose and remove the cartilage He should remember however that a very small incision which requires excessive traction on the soft tissues defeats its own purpose For an excellent review of the various incisions by which the knee joint may be approached reference can be made to the article of Abbot and Carpenter [8] on "Surgical Approaches to the Knee Joint." The entire cartilage should be removed This procedure has been rendered somewhat more easily performed

by the introduction of the Low Breck, the Downing and the Smillie cartilage knives

The advent of hydrocortisone acetate (compound F) promises to be of value in lessening postoperative reaction. One cubic centimeter can be deposited in the joint before closure of the wound. Its use is still empirical but early results are quite encouraging It is important to control all bleeding before wound closure Since the operation is usually done with a tourniquet on the thigh, it must be remembered that there will of necessity be some vessels present which are closed by natural coagulating process and not by ligation The use of compression dressings postoperatively is important, to help prevent loosening of these clots with resultant hemarthrosis If such an accident should occur early aspiration and reapplication of the pressure dressing is indicated Early resumption of quadriceps exercise and straight leg raising against gravity is imperative. Flexion should be started cautiously about the fourth or fifth day In this era of early ambulation, there is a tendency to have patients bearing weight as early as ten days after operation The writer is reactionary enough to feel that one should not ambulate on pathology and most postmeniscectomy patients seem to be of the same mind Few of them will attempt to walk without support at such an early stage and in most cases support (crutches or cane) must be continued for about three weeks

The Quadriceps Apparatus

The anatomic considerations required for an understanding of injuries of this apparatus have been mentioned sketchily in the early part of this chapter Injuries to the mechanism serious enough to require treatment are relatively common, and are due usually to forcible flexion of the knee while the quadriceps is held taut

Ruptures of the Quadriceps Tendon Most commonly the quadriceps tendon tears at or just above its attachment to the superior pole of the patella If the tear occurs at the patella it may pull with it bony fragments of variable size The tear may extend entirely through the tendon or may involve only a portion of its thickness As in ruptures of the gastrocnemius tendon it is frequently found that the involved segment is usually the site of a preexisting degenerative process For this reason a rupture should be repaired as soon as the immediate reaction to trauma has subsided. Since rupture is so often accompanied by hemarthrosis and exudation into the surrounding tissues it may at times be necessary to wait seven to ten days after the injury The prognosis is uncertain as to complete restoration of function and repair is frequently made difficult. If repair can be done early simple suture with nonabsorbable material may suffice Severely shredded edges, however and late repair with fixation of the edges in a retracted position may require the use of fascia or tendon grafts Mobilization at the earliest moment consistent with safety is essential if a good range of movement in the knee joint is to be expected Quadriceps function should be started cautiously within forty-eight hours after repair

The Patella

Rupture of the Patellar Tendon These are far less common than quadriceps tendon tears, probably because of the proportionately greater bulk of the patellar tendon and the less dynamic

quality of its function Such tears when they do occur however are very disabling and require immediate repair Suturing, as in quadriceps tendon repair may at times be quite simply done, but if operation is delayed for a period of weeks or even months as sometimes happens it is extremely difficult to obtain a satisfactory end result As in the quadriceps repair the use of nonabsorbable material may suffice in simple tears In late cases where the edges have retracted and the patella is pulled up above its normal level, the use of fascial or tendon grafts may be required to secure and maintain apposition Because of the need for relatively lengthy immobilization superimposed on the effects of the original trauma and the operative trauma, a long period of rehabilitative care may be expected.

Dislocation of the Patella Most of the patients treated by the writer for this condition have been females Most of them have been in their teens or early twenties but in all cases the initial displacement occurred during the period of early adolescence. Almost all cases have been bilateral Most of the patients have had a bilateral valgus deformity of the knees In all cases the displacement has been to the lateral side. The textbook finding of a small, flat lateral femoral condyle a large normally formed medial femoral condyle and a "tear drop" patella has been, like most text book findings, uncommon. In only one case has this "classic" picture been demonstrated on roentgenograms More commonly both condyles are small and poorly developed At operation it has been found that the articular surface on the anterior aspect of the femur has been broader on the lateral than on the medial condyle This is easily understood when one remembers that because of the valgus deformity of the knee the line of pull of the patella across the joint lies more nearly over the lateral condyle than over the intercondylar notch In one case it was found that articular cartilage covered only that portion of the medial condyle which immediately adjoined the notch

These findings indicate that there is unquestionably a developmental predisposition to recurrent dislocation of the patella, and in such cases the initial dislocation results from relatively minor trauma. Succeeding episodes however may occur on simple flexion of the knee

In individuals of normal development, lateral dislocation of the patella is relatively rare, and results usually from rather severe trauma. In either event, dislocation is accompanied by some degree of disruption of the medial portion of the quadriceps expansion. This may vary from simple stretching to a longitudinal tear usually along the medial margin of the patella. The result is a laxity of this expansion, which further increases the likelihood of recurrence of the displacement.

Late pathologic consequences of repeated dislocations are the development of chondromalacia of the patella and the femoral articular surfaces the formation of osteophytes along the patellar and femoral articular margins and the presence of loose cartilaginous or osteocartilaginous bodies within the joint.

The diagnosis of this condition is usually quite simple More often than not, the patient announces it on entering the office. If there has been a recent episode the knee will usually be swollen and there may be a moderate

amount of joint effusion. Tenderness may be diffuse but is usually sharply localized along the medial border of the patella. Because of the fact that the joint becomes unstable and unpredictable and since the episodes are quite painful most of these patients are quite apprehensive and are particularly apt to protest if the examiner attempts to test the mobility of the patella. If no recent dislocation has occurred there are no definite diagnostic clinical findings. The patella may or may not be smaller than normal, and it may or may not be located higher than its normal level. There is usually a bilateral valgus deformity of the knees. Flattening of the lateral condyle is very difficult to appreciate clinically especially if the knees are symmetrically developed. This holds true also for underdevelopment of both condyles. There may be some restriction of flexion in cases of long standing. Even in quiescent cases the patient is usually most reluctant to permit examination of the mobility of the patella.

Roentgen examination, as noted above does not commonly show the classic" picture. More often than not, the only finding present will be that of a periosteal or cortical tear along the medial border of the patella, and this can usually be appreciated only on the axial patellar view.

There is only one modality of treatment which can overcome this condition and this is surgery. Delaying surgical intervention and permitting repeated dislocations to occur can only serve to increase the intra articular pathology. As a result, when surgery is finally undertaken, it cannot be expected to produce a really satisfactory end result.

There have been several operative procedures devised, but only two have retained any popularity. One is the Goldthwaite procedure in which the patellar tendon is split lengthwise, its lateral half detached from the tibial tubercle passed deep to the medial half then anchored as far medially as possible on the upper end of the tibia. More commonly used is the procedure in which the entire patellar tendon is transplanted together with a block of bone from the tibial tubercle to a bed cut into the cortex on the medial aspect of the tibia. In any repair a lax medial quadriceps expansion should be reefed and the writer feels that in all cases the joint should be opened and explored so that intra articular pathology may be corrected.

The Synovia and Bursae

Bearing in mind that since the knee is the largest joint in the body its synovia must of necessity be the most extensive. Its surface area is greatly increased by the many villous projections and fibrous or fibroareolar folds which it covers. One of the largest of these folds separates the quadriceps pouch from the synovial cavity of the knee joint proper. There is a constant opening between these two spaces so that there is a free flow of fluid from one to the other. The quadriceps pouch because of this free communication is considered part of the knee joint synovial cavity. Functionally it is a very large bursa which allows a free gliding motion of the lower portion of the quadriceps mechanism over the lower most part of the femoral shaft and the condyles. Its tremendous importance can be readily appreciated when one considers the serious loss of function consequent upon its being obliterated by trauma. The quadriceps apparatus

having lost its gliding action becomes a check rein which prevents knee flexion

There are other bursae about the knee which may become involved in trauma The commonest of these is the prepatellar bursa which is subject to acute injury but more commonly is affected by the long continued trauma of occupations which require constant kneeling on hard surfaces Less commonly the infrapatellar bursa may be injured Its more protected location deep to the patellar tendon and its smaller size make it of far less surgical importance than the prepatellar bursa Of occasional interest is the semimembranosus bursa, between the lower portion of the semimembranosus tendon and the medial head of the gastrocnemius This may be injured by a direct blow or may be involved as a part of a severe sprain In some individuals this bursa communicates directly with the joint space and may become enlarged as part of a joint effusion Smillie[3] describes variations in the bursae on the posterior and posteromedial aspect of the joint, and concludes "So called Baker's cyst and semimembranosus bursa are one and the same condition" Lying on the anteromedial aspect of the upper tibia is an inconstant bursa which has received very little attention in the literature It is found deep to the anserinus tendon and while it cannot be considered an intimate part of the knee joint, it rarely becomes involved except in the presence of other knee joint pathology Affection of a similar bursa deep to the biceps tendon on the lateral aspect of the knee is another condition which does not receive its proper appreciation as a source of pain in the region of the knee

There is no reason to doubt that the synovia can react to trauma and that this reaction is manifested by an increase in the formation of synovial fluid and an alteration in its chemistry It is difficult, however to conceive of any trauma which will affect the synovia alone other than a direct blow over an exposed area There is certainly some justification at times for the diagnosis of "acute traumatic synovitis" It is likely that acute synovitis is not too often a distinct isolated entity More commonly the synovial reaction is probably the result of concomitant injury to some other component of the joint structure such as a ligament sprain or cartilage injury Persistent synovial thickening or effusion after a trauma may justifiably be called "chronic traumatic synovitis" Such persistence however is almost certainly due to the presence of some other intraarticular disorder

Traumatic arthritis uncorrected ligament or meniscus injuries an aggravated hypertrophic arthritis or a reactivated rheumatoid arthritis are all potential causes of persistent synovial thickening One must think, too of the possibility of low grade specific infections, such as tuberculosis or lues

Acute bursitis in the absence of pyrogenic infection is best treated by aspiration, followed by compression dressings If effusion continues to take place after repeated aspirations excision of the bursa is indicated An infected bursa must be treated like any other abscess Incision and drainage and the use of antibiotic or chemotherapeutic drugs are in order Chronic bursitis will rarely respond to aspiration, and excision is required if the enlarged bursa is the cause of disability The use of sclerosing solutions to ob-

literate bursae is accompanied by the risk of having such solutions leak into the joint cavity through an unsuspected communicating channel

Acute synovitis is treated by aspiration and compression dressings As pointed out elsewhere a single aspiration may not suffice and repetition of the procedure may be necessary Associated injuries must be given their proper share of attention if treatment is to be complete Chronic traumatic synovitis should lead to an awareness of the likelihood of its being secondary to other pathology Any attempt to treat it as an independent entity will probably fail. The administration of diathermy three times a week for months on end, as is done by some will not cure patients

NONFRACTURE INJURIES OF THE ANKLE JOINT

Smaller but somewhat more prone to injury than the knee joint is the subjacent conglomeration of bones, ligaments and articular surfaces called the ankle joint The complexity of its structure and the compound motion of its component parts are subject to great under appreciation A sudden misstep on an uneven surface a quick twist, a sharp snap and a wave of nauseating pain add up to a hit and run diagnosis of "sprained ankle" Seldom is any thought given to the fact that the lower tibiofibular articulation may have been torn apart, or that a fragment of bone may have been avulsed from one of the malleoli No consideration is usually given to the fact that motion at the tibio-talo-fibular articulation takes place only in a vertical plane and that horizontal motion occurs only in the subtalar joint The horizontal motion, moreover is not a simple one but is accompanied by a slight rotation of the calcaneus under the talus

Twisting injuries of the foot and ankle should be given the respect which is demanded by the pathologic possibilities No injury of this region should be treated without roentgenograms Routine anteroposterior and lateral views moreover are not always adequate An oblique view which opens up the lower tibiofibular articulation should be included Routine views cannot distinguish the extent of soft tissue injury A partial tear of a ligament cannot be distinguished from complete rupture on the ordinary views The addition of an anteroposterior view with the foot strongly inverted is desirable if the injury seems to be of any magnitude This may require the use of anesthesia at least locally Such a view may reveal that rupture of the lateral ligament has been sufficiently extensive to permit dislocation of the talo-tibio-fibular articulation. X rays which reveal only the tibio-talo-fibular and the subtalar joint may miss the real pathology The entire midtarsus should be included so that fractures of the neck of the talus avulsion fractures of the os calcis and fractures of the base of the fifth metatarsal may be detected if present

The diversity of complaints following twisting injuries of the ankle is easily understood when the number and complexity of its ligamentous structures are considered. There are ligaments joining the tibia to the fibula, the tibia to the talus calcaneus and navicular the fibula to the talus and the calcaneus the talus to the calcaneus and navicular the calcaneus to the cuboid and navicular and the cuboid to the navicular Anyone or more of these ligaments may be the offended member

Most commonly the external lateral ligament is torn usually in its antero-inferior portion This is the so-called simple sprain Less often as a result of an everting force the medial lateral (deltoid ligament) may be torn In each of these injuries the pain and tenderness are usually well localized and there are swelling and edema at the site of injury The smaller ligaments which join the bones of the tarsus are not commonly injured by themselves More frequently such injury is an accompaniment of a more severe sprain of either the medial or lateral ligaments

The treatment of simple sprain once the diagnosis has been definitely established, is usually ambulatory The present vogue is to infiltrate procaine (5 or 10 cc of a two per cent solution) directly into the tender area then have the patient continue to ambulate Although this was first recommended by Leriche in 1928 it attained its greatest popularity during World War II when the literature was flooded with reports on its use in the Armed Forces Bearing in mind the fact that the patients reported on were in general a younger more rugged type of individual than one sees in ordinary private practice, it is easily perceived that one will occasionally encounter a skeptic who does not believe that his ankle no longer hurts just because the doctor put some procaine in it. This is particularly true if the patient happens to be elderly or a female who refuses to be seen without high heeled shoes It will be true also if the procaine was instilled into only one of two or more affected areas. It will be well, therefore for the average practitioner to remember the principles of the art of strapping. The adhesive plaster boot designed by Gibney is rather extensive and not always required In general a sprained ankle is best supported by anchoring the adhesive on the well side of the foot just below the malleolus passing it under the plantar surface then carrying it well up onto the leg on the affected side

The writer has had no experience with the practice of spraying the injured area with ethyl chloride nor of blocking the sural nerve with procaine [7] Of the two the latter seems by far the more rational The writer's experience with intravenous procaine to control pain and swelling in injuries of the lower extremities has been very disappointing

Dislocations of the ankle, or midtarsal joints are injuries which fortunately are not too common, but unfortunately may be missed if complete x ray study is not done Diastasis of the lower tibio-fibular articulation must be completely reduced. If it cannot be reduced and properly held by ordinary closed methods then a long screw or a nut and bolt should be passed through the two bones just above the ankle joint to hold them Dislocation of the talus associated with complete rupture of the external lateral ligament must be treated by rigid plaster immobilization for a minimum of eight weeks. Lateral dislocation, due to complete tearing of the deltoid ligament is rarely seen except in association with malleolar fractures Posterior dislocation of the talus usually requires a fracture through the posterior tibial malleolus, and there are usually associated fractures of the external and internal malleolus

A complete subtalar dislocation carries with it the grave danger of nerve and vascular damage Even if the main

vessels and nerves be intact, tension of the skin over bony prominences carries with it the risk of pressure necrosis and this can happen with amazingly unsuspected rapidity It should not be necessary to point out the urgent need for immediate reduction of such a dislocation Dislocation at this joint is frequently compounded because of the tremendous tearing force to which the skin is subjected Since this compounding takes place from within and is not the result of a crushing external blow immediate debridement and repair of the wound and reduction of the dislocation will usually succeed If there is no compounding of the injury closed reduction should be done In either case rigid plaster immobilization for eight to ten weeks is required.

The writer has seen only one case of dislocation at the tarsometatarsal joints The entire group of metatarsals was displaced plantarward on the metatarsals This case required open reduction

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PHILIP LEWIN M D

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The Management of Acute Low Back Pain

Introduction The bones of the spine are not like the tibia or the skull The vertebrae are more like sponge candy than curbstone Between each two bones there is a cushion-like structure called the intervertebral disk made up of cartilaginous material with a nucleus This acts like a cushion or a bumper

Then we have the spinal cord with its spinal nerves that go to the muscles and skin of the arms legs and torso Next we have the sympathetic nerves with special functions and duties

The human back is one of the mechanical wonders of the world *

It is composed of bones joints muscles, nerve blood vessels, ligaments cartilages, and disks

There are thirty three bony segments in the back Beginning at the back of the head and going down, these are listed as seven cervical vertebae which are movable on each other and at both ends five lumbar segments which are movable five sacral segments which are fused as one and four coccygeal segments which are also fused The juncture between the lumbar and sacral vertebrae is a frequent location of trouble "Dislocation" of the coccyx may occur at the sacrococcygeal joint.

Between each two vertebrae in the neck thorax, and lumbar regions there are joints which permit a small amount of forward and backward movement. Side movement and twisting or torsion are possible only because the vertebral bodies turn and slide on each other Between each two vertebrae there is a cushion, bumper or shock absorber called an intervertebral disk There are thirty-three disks each made of strong, stringy circularly arranged cartilage-like tissue with a central nucleus of gelatinous material The disks have assumed increasing clinical importance during recent years

The muscles of the back are among the strongest and most numerous of the body Some are large, others are tiny Each muscle works in conformity with well known mechanical principles of leverage

The great stability of the back is provided by the muscles, and especially by numerous powerful tenacious ligaments

To every one of the soft tissues of the back nature supplies nerves In addition to supplying motor and sensory nerves for muscle movement and sensation to the tissues of the back, there are spinal nerves which carry impulses to the arms legs, thorax, and abdomen.

*This is condensed from the author's article which appeared in Hygeia, Dec. 1945

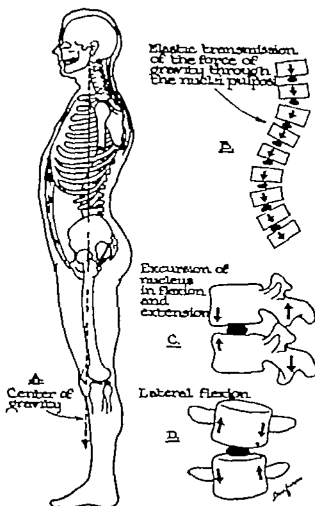


FIG. 1 The mechanics and dynamics of the lumbosacral area. Balance and transmission of force. (Adapted from Calve and Galland)

The spinal cord is situated in the spinal canal which is a long bony tube made up of segments furnished by each vertebra.

Among the unique features of the human body are the numerous small apertures of the spine, foramina, through which nerves pass from the spinal cord, to convey nerve impulses to muscles and other tissues outside the spine

The illustrations in this chapter are from the author's book, Backache and Sciatic Neuritis, and are reproduced through the courtesy of its publishers, Lea & Febiger Philadelphia, Pa.

In addition to the central nervous system, every human back has an automatic mechanism called the sympathetic nervous system

Physiology means the function or purpose of the living tissue, individually and collectively to carry out nature's desires and directions Biomechanics means living function in action.

The spine bears a relation to the human body crudely similar to that of the tent pole of a circus or to the mast of a sailing ship It supports the torso or trunk It produces length and height

of the human being Its muscles supply movements of the back abdomen, and chest It manufactures important blood elements and acts as a storehouse for calcium and other chemical substances.

In a manner similar to all living tissues, the back structures are in a constant state of flux *i.e.* anabolism and catabolism

Human beings are constantly and continuously building destroying, and repairing our bodily tissues The remarkable feature is that the various processes are going on simultaneously synchronously and reciprocally

The spine is like a building that is constantly deteriorating to an infinitesimal degree but at the same time is being reconstructed therefore the spine is self-destructive and self-reconstructive It is self-sustaining its joints are self lubricating and self adjusting within wide limits In addition it is motorized by its muscles so that one might say "All this and automatic power too"

When one stops to consider the intricacies of the back, he soon realizes that a human being is the product of the Master Builder Who has combined the skill and resources of the bridge builder the ship builder the railroad builder the structural iron worker the carpenter the steam fitter the electrician and the plumber

Next, consider the function of circulation The tissues of the back are supplied with blood by a pipe line system of various sized tubes The finest capillaries are almost as delicate as those in the eyeball or the brain

The spinal cord and the central nervous system form an electric cable and message center that is more wonderful than the finest telephone and telegraph exchange center

Scientists boasted when they perfected the transmission of a two-way conversation over the same copper wire Yet a person can send thousands of impulses up and down the spinal cord at one time

In addition there are nature's "trouble shooters" that localize troubles that occur along the circuit. There are signs and symptoms and tests which indicate the nature of the disturbances and where they are located Besides all this, the back has automatic control

There have been several epochs or milestones in the medical history of back complaints some of which were considered to be fads Along these diagnoses were lumbago railway spine sacroiliac dislocation or displacement and hypertrophic arthritis At the present moment, interest is centered on the intervertebral disks and their disturbances.

Causes of Backache Some of the every day acts that may cause backache are

Raising a window that is stuck This may occur in the home or office or in a street car or train.

Kicking a football and connecting or missing.

Missing a step especially on stairs.

Arising suddenly from a stooped position.

Picking up grass on the golf course to see which way the wind is blowing.

Extricating locked auto-bumpers.

Handling a suitcase on a Pullman car

Sneezing, especially by an asthmatic or hay fever victim.

Climbing a ladder or reaching for objects that are too high.

Standing on a stool or chair and slipping.

Lifting a heavy child from side to side.

A structural iron worker standing on two beams and lifting a keg of rivets.

Moving furniture in the office, especially putting a rug under the desk.

A slip on the ice.

Shoveling snow

Sitting in a cramped position such as doubled up in a Pullman car seat.

A surgeon operating for a long time, in a cramped position.

A dentist standing at his chair for many hours.

Sitting in a cramped position in a crowded automobile

Sitting in a bath tub with legs outstretched and reaching for the soap or sneezing.

Stooping to pick up a collar button that has rolled under the dresser

A man lifting his son's bicycle from a level lower than the one on which he is standing.

the back abdomen, and pelvis The food that makes for obesity does harm in two ways firstly the simple mechanical overweight and secondly by the chemical toxins produced by the break down of the food

The term "psychosomatic" means the relation of the mind to organic trouble There is a trend among some physicians

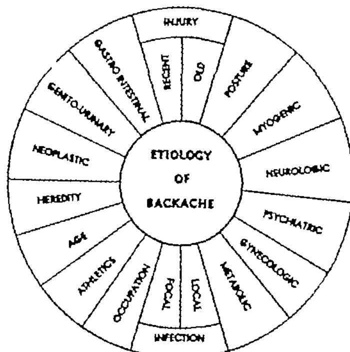


FIG —

The efficiency of a person's back is directly proportionate to his original endowment his posture muscle power ligamentous support metabolism bone structure and excessive or continued stress and strain

Backache in men past fifty years of age is frequently due to prostate trouble in females it is often due to disorders of the pelvic organs Obesity may bear a close relation to some back troubles both in males and females. Overweight causes extra stress and strain on the muscles and especially the ligaments of

today toward emphasizing the mental attitude of the patient toward his back trouble The danger of this lies in the neglect of a complete history a complete physical examination and adequate x-rays of excellent quality and sufficient coverage Very often backache is a defense mechanism that is an escape from an undesirable situation There are three conditions I shall dispose of by simple definitions Firstly exaggeration, or overemphasis of an organic condition secondly malingering or willful exaggeration of a complaint for specific gain

thirdly hysteria an unconscious phenomenon. Many persons have to learn how to live with their backache

A careful examination of the back is the basic foundation of an accurate diagnosis This study often includes examination of other parts of the body such as the head neck chest, abdomen pelvis legs, and feet The accurate interpretation of symptoms is based upon extensive knowledge and wide experience

Cooperation of the roentgenologist, neurologist, and orthopedic surgeon is essential in determining the exact situation of the lesion involved in the production of backache The importance of good x rays cannot be overemphasized In order to be of maximal value the x-rays must be of excellent quality and cover a sufficient area X rays may be deceptive both positively and negatively Oftentimes, normal x-rays are of definite diagnostic value

The patient with back trouble is interested in one or more of three things all of which begin with "D" These are discomfort, disability and deformity Discomfort means pain or tenderness during the day or night during activity at work or play Disability means inability to perform the usual activities of the person's age it means loss of normal function, which includes alertness coordination, strength, and endurance at work, at play or in the home Deformity means disturbance of normal shape or posture

A person can inherit a "weak" back, just as he can inherit red hair blue eyes large tonsils or flat feet. Some families have specific individual familial or abnormal mechanical characteristics

There are, however many variables in people, even in brothers and sisters There are many variables in responses and reactions to the causative factors of back pain and to treatment Neglect of minor symptoms or injuries aggravated by fatigue or overwork may cause serious consequences

The types of back troubles that are amenable to manipulative treatment, must be carefully determined One may ask himself "How is my back standing up under the strain and how am I standing up under my back strain?"

Of all the ailments to which human flesh is heir backache may be as puzzling as any It is evident to any intelligent person who takes time to reflect on the numerous causes of back troubles and the multiplicity of affections that there is no one magical formula for the treatment of all back disorders. The wise person is opposed to the employment of one form of treatment for all types of back troubles

When a person entrusts his back to certain individuals who have not had proper training, knowledge, and experience it is like taking a Swiss watch to a riveter in a ship yard for needed repairs.

The Riddle of Your Backache

Your backache is due to

A subluxation, says the chiropractor

Nerve pressure is impeding the flow of nerve force from your brain to your body says Palmer

The structural integrity of your body mechanics is disturbed, says the osteopath.

Your uterus, say certain gynecologists.

Your tubes, say others.

Your prostate, says the urologist.

Your gout, say some internists.

Foci of infection said Billings.

Your prolapsed intervertebral disk, say certain surgeons like Mixter and Love.

Bridging of your piriformis muscle by the sciatic nerve, say Yeoman and Freiberg

Your coccygeus muscle, says Thiele

Your hypertrophied ligamentum flavum, say Spurling and Naffziger

Your tensor fasciae femoris, says Ober
Adhesive ligamento-thecitis, says Lewin.
Your erector spinae says Heyman.
Your episacroiliac lipomas, say Ries and Liefendahl.
Your intervertebral articulations, says Putti.
Your intervertebral foramina says Sicard
Radiculitis, ganglionitis, funiculitis, or plexitis.
Your vertebral foramina, say Danforth and Wilson.
Your posture says Goldthwait.
Your sacroiliac joint, says Smith Petersen.
Your lumbosacral joint says Ryerson.
Your old vertebral epiphysitis, says Calve.
Your kyphosis dorsalis juvenilis, says Scheuermann.
A non-stop lumbar puncture
A fall on your buttocks and coccyx, say many
Your feet, says the Canadian foot twister Locke.
Your Schmorl's nodes, say a few
Typhoid shots, says Blaine.
Your fascial adhesions, says Gratz.
Your myofascitis, says Albee.
Your lumbago say many
The posterior divisions of your spinal nerves, says Steindler
Arthritis, arthrosis, neuritis neurosis, fibrositis, myositis and fascitis.
A tumor of your cauda equina says the neurologist.
Your articular facets, says Ghormley
Your sinuvertebral nerve is pinched, says Steindler
It's your zygoapophysitis says Barr
It's a prespondylolisthesis.
No, it's a spondylolysis.
It's a separation of your neural arch, says Willis.
It's an isthmus lesion, says Chandler
It's hysteria, says one
Malingering, claims another
Exaggeration, says the third an insurance *company doctor*
You've been shoveling snow
You slipped on a stair
You kicked at a football and missed
You tried to slip a rug under your office desk
You cranked your car
You tried to unlock your auto bumper
Too much rough housing with your husky boys.
Too much copulation says your physical trainer
You tried to open a window that was stuck.
Your high heels—no your low heels.
Your sway back—no, your pot belly—say the posture experts.
Your syndesmophytes, says Forrestier
Localized osteospondylitis, says Campbell.
It's sacrarthrogenetic telalagia, say Pitkin and Pheasant.
You've got Erickson's railway spine, says the shyster lawyer
Your lawyer wants a greenback poultice for him and you.
You're a professional accident monger says the cab company lawyer
Your childhood repressions, says the psychiatrist.
YOU HAVE NO BACKACHE—says the Christian Scientist

The Chief Low Back Syndromes. Sprain, strain, lumbago, lumbosacral derangements, spondylolisthesis facet disorder foramen disorders, disk syndromes, sacroiliac disorders arthritis episacroiliac subfascial lipomas (E S-I L bodies) neoplasms, traumatic fractures and dislocations

TREATMENT The treatment of backache is either operative or nonoperative The operative measures might include manipulation laminectomy hemilaminectomy hemifusion or fusion of the spine The nonoperative measures include cast, traction brace, belt, pelvic strapping, pelvic balance crutches, physical therapy manipulation caudal epidural injection treatment of foci and psychological

Leg traction should be given with the pelvis strapped and the foot of the bed elevated so that the body serves as countertraction When traction is applied to the head, the head must be elevated for countertraction

One morning my houseman reported a backache due to shovelling snow from my driveway I proceeded as follows

1 Ethyl chloride spray of entire lumbar and lumbosacral area

2 Krylon spray to skin of entire pelvic, lumbar and abdominal areas
3 Application of two squares of 17.5x17.5 cm. (7x7 inches) of chiropody felt (J & J) to regions of groins and anterior iliac spines

tions, alcohol and caudal epidural injections Psychiatry myotomy tenotomy of the erector spinae and tensor fasciae femoris bursectomy ligamentotomy ligamentolysis lipomectomy laminotomy hemilaminectomy laminec-

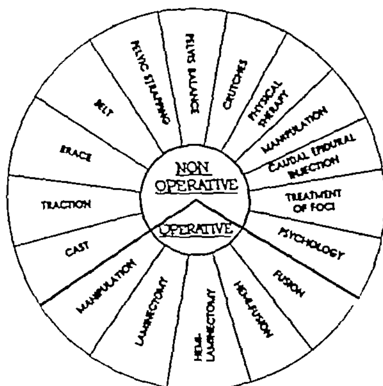


FIG. 3 Treatment of backache.

4 Application of adhesive tape to entire pelvic, lumbar and abdominal areas

The answer to *The Riddle of Your Backache* depends upon ambulatory or recumbent treatment. The factors are physical, medicinal, psychological and surgical. They include Rest, hard mattress, pelvic strapping a pelvic belt, physical therapy traction, diet, vitamin B_1 vaccine, sulfur gold, bee venom massage of piriformis and coccygeus volcanic mud, hot paraffin, manipulation special shoes crutches, plaster casts braces corsets local injections of normal salt, novocain sclerosing solutions, alcohol and caudal epidural injections Psychiatry myotomy tenotomy of the erector spinae and tensor fasciae femoris bursectomy ligamentotomy ligamentolysis lipomectomy laminotomy hemilaminectomy laminectomy laminectofusion, hemifusion fusion, chondromectomy facetectomy

The Conservative Treatment of Backache

Basic Principles
(1) Make patient comfortable at all costs.
(2) Investigate later
(3) X-rays later
Hypodermic injection of demerol
Ethyl chloride spray
Americaine spray and massage.
Procaine injection of trigger points.
Manipulation without anesthesia.
Adhesive strapping of pelvis.
Rest in bed.
Fetal posture if comfortable, flexion of head, neck, torso hips, knees.

Rigid board under mattress—depending on response.
Foot board in bed.
Salicylates
  By mouth.
  By rectum.
Tolserol
  By mouth.
  Intravenous much better
Myanesin—Mephanesin—orinoxin.
Curare
Pabalate—bufferin.
Empirin with codeine.
Hypodermic injection of morphine.
Procaine intravenously
Seconal *for sleep.*
Traction
  Intermittent
  Continuous
    Pelvis, Legs, Head.
Crutches to go to lavatory or
Commode at bedside.
Plaster cast.
Brace during day while ambulatory—must be comfortable.
Belt or corset while in bed.
Corset reinforced
Hot tub baths.
Physical Therapy
  Infrared.
  Short wave soothing.
  Massage as tolerated.
An electric blanket
  Low heat.
  A lighted cradle
X-ray therapy—radium.
Manipulation under anesthesia.
Psychotherapy
Posture chairs.
When ready to walk
  Balance pelvis.
  Crutches.
  Pads in shoes.
For Arthritics and Neuritics.
  Compound E.
  Compound F
  ACTH
  Butazolidin.
Reserve Trump Card
  Immediate anesthesia and examination, or very gentle manipulation.
  Diet—optimal for each person.
  Reduction of weight—if indicated.
  Control water retention.
  Attention to fat deposits.

Don't let anyone tell you that tolserol given by mouth is "just as good as tolserol given intravenously" It is not.

Some experts are "playing it down" Others are "playing it up" It is like a special instrument in an orchestra. Any symphony conductor will tell you he doesn't call on the oboe player or the French horn in every selection

General Advice *Frequent change* of activity may prevent trouble. The continuous use of a certain group of muscles predisposes to strain.

No amateur should

1 Shovel snow 2. Rake leaves 3 Work in a garden 4. Work on a farm	for more than thirty minutes at one time.

Every person with backache should be advised concerning the type of bed to use A soft mattress may aggravate a backache Most patients sleep more comfortably on a firm bed. A piece of plywood between the mattress and the springs will accomplish this. There are several combinations of springs and mattresses that provide this service Some patients can sleep better on a cushion on the floor than in a bed, chiefly because of the firm foundation. (Fig 4)

Body posture is important in standing, sitting, and lying.

One patient gave a history of previous health but on arising one morning to go to the bathroom he fell with terrific pain in one leg. On arrival at the hospital he was given 100 mg (1½ grains) of demerol hypodermically and placed in the fetal position, *i.e* the tumbling position with head, neck torso, hips and knees flexed

He was then massaged with Americaine from a spray can, and the skin protected front and back with a coat of sealskin The skin in front was covered with a sheet of muslin 25 by 62.5

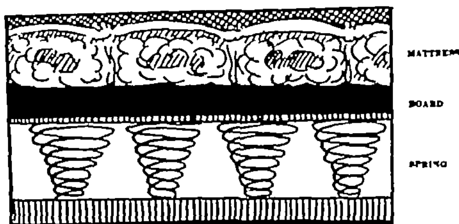


FIG. 4 Simple way to make a mattress rigid. Insertion of board under mattress.

cm. (10 by 25 inches) Felt pads were placed over the hip bones and the entire pelvis strapped with rigid adhesive tape. After this an electric pad under low heat was applied continuously to the lumbosacral area

For medication the patient was given 4 Gm. (1 dram) of sodium salicylate in 60 cc (2 ounces) of warm tap water as a retention enema immediately followed by 2 Gm (30 grains) given in the same way every four hours until the pain had disappeared or the patient became deaf Intravenous tolserol was given very slowly

I told his wife he had a protruded intervertebral disk below either the fourth or fifth lumbar vertebra, with compression of a spinal nerve. I impressed her with the fact that he would be relieved of this attack within seventy two hours but that according to the law of probability he would have recurring attacks and it would be wise to have surgery sometime during a future severe attack

The next day I ordered a low back cage brace to be worn when he was ambulatory and a reinforced corset to be worn at all other times except when in the bath tub or while getting physical therapy

The strapping was removed on the third day and the corset used as a substitute so that radiant heat, gentle massage, and soothing inductotherm could be administered.

When he was ready to walk, on the fifth day, I ordered two crutches and inserted heavy cushion felt pads in his shoes

This is a "run of the mill" case

Some surgeons would advise surgery and some of them would be right, in some of the cases However I feel that every case of backache has the right to at least one session of conservative treatment. I am confident that no person will suffer irreversible or irremediable harm if the period of watchful expectancy is under the supervision of a competent physician

My readers will be surprised that nothing has been said up to this point about a minute complete history of the case a physical examination including a neurological sutdy routine, and special x-ray projections, lumbar puncture various laboratory tests, myelography diskography traction, intravenous procaine or injection of trigger areas

Nothing has been said about a prostate examination or search for a primary neoplasm

Well these critics may be quite right. However when one is confronted by a case as described, the important immediate targets are

1 Relief of pain
2 Dispersion of muscle spasm.

You must release at least one jaw of the nutcracker that is squeezing a nerve

THE INTERVERTEBRAL DISK SYNDROME*

The intervertebral disk has been the object of study for several centuries In 1555 Vesalius described the difference between the consistency of the annulus fibrosus and that of the nucleus pulposus Virchow made anatomic studies of the intervertebral disk in 1857 and one year later von Luschka accurately described its structure and embryology Between 1855 and 1880 various writers made contributions to the embryology stressing the importance of the fetal notochord.

In 1927 Schmorl began his meticulous necropsy studies showing the high incidence of displacement of the nucleus pulposus into the spongiosa of the vertebral body Schmorl and Andrae called attention to the cartilaginous masses found within the spinal canal consisting of nucleus pulposus herniated through defects in the annulus fibrosus

The modern concept of the syndrome of protrusion of intervertebral disk dates from the work of Mixter and Barr Adson Love Craig, Camp Walsh Dandy and Bradford and Spurling.

The first case of intervertebral disk herniation to be described clinically was that of Kocher in 1896 Since 1934 a voluminous literature has accumulated

The first published report of a patient operated on for protrusion of an intervertebral disk into the spinal canal was that of Oppenheim and Krause in 1909 Their patient had a complete transverse lesion of the cauda equina at the level of the third lumbar disk. The protruded portion of a disk was removed at operation and the patient recovered Goldthwait in the United States and Middleton and Teacher in England reported cases in 1911 Adson performed his first operation for this lesion in 1922 Numerous reports of "enchondromas" appeared between 1911 and 1929 In the latter year Dandy reported two lumbar cases and recognized the distinct character of the lesion. Peet and Echols also recognized the lesion about the same time Schmorl recognized the frequency of protrusions from the disk margins but did not consider them of great neurologic significance

The interest of Mixter and Barr was aroused in 1932 by the case of a young man with severe intractable sciatica following a fall They found that about seventy five per cent of their enchondromas were not tumors but protrusions of normal disk cartilages In 1934 they called attention to the fact that unilateral leg pain was the outstanding symptom suggesting a protruded disk It is remarkable how close many investigators came to discovery of the disk syndrome This is especially true of Danforth and Wilson and Williams Ghormley Putti Adson, Dandy Bucy Goldthwait Barr and others

The nucleus is capable of absorbing sixteen times its weight of fluid

Ventral Extradural Chondromas Formerly small localized masses extending into the ventral part of the spinal canal opposite the intervertebral disks were considered true neoplasms and were designated by various terms

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* Reprinted from Journal International College of Surgeons, March April 1948

Chrondroma ecchondrosis, fibroma and fibrochondroma

Two "chondromas" of the lumbar intervertebral disks were reported by Ott and Adson (1923) In 1928 Elsberg reported eleven "chondromas" involving intervertebral disks, and Stookey reported seven cases all cervical Alajouanine and Petit Dutaillis recognized that these "chondromas" consisted of the displaced nuclei pulposi of the intervertebral disks The report by Elsberg of fifteen patients with "chondromas" been displaced into the vertebral canal In the same year Goldthwait (1911) produced excellent theoretical arguments to prove that as a result of trauma the substance of the intervertebral disk might cause compression of the cauda equina He made this diagnosis in a patient with motor sensory and sphincter paralysis Exploration by Harvey Cushing revealed only a narrowing of the osseous canal at the lumbosacral junction The history was so characteristic that it appears quite probable that

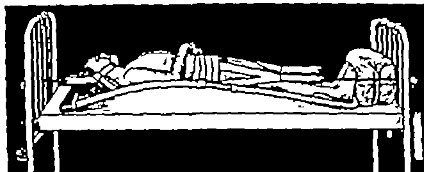


FIG. 5 Head traction and pelvic traction combined with treatment on a curved Bradford frame.

proves the similarity between certain parts of the intact intervertebral disk and the "chondroma." Kocher (1896) recorded the first account of traumatic rupture of the intervertebral disk.

Middleton and Teacher (1911) reported the case of a patient who lifted a weight without suffering much distress, but later the same day experienced pain in his lower extremities followed by flaccid paraplegia. Examination revealed anesthesia up to the inguinal ligaments, absent knee and ankle jerks and incontinence of both sphincters. The patient died sixteen days later Opposite the intervertebral disk between the twelfth thoracic and the first lumbar vertebrae was found a mass of the pulp of the intervertebral disk which had a ruptured disk was overlooked (possibly a concealed disk)

Dandy in 1929 reported two cases in each of which loose cartilage from an intervertebral disk caused compression of the structures within the spinal canal. He thought that the entire posterior part of the intervertebral disk was separated and displaced rather than that the nucleus pulposus composed the greater part of the mass

By intimate cooperation between neurosurgeons and orthopedic surgeons a new chapter in the etiologic diagnosis of sciatic pain has been written. In 1934 Mixter and Barr demonstrated that root compression as a result of pathologic changes in the intervertebral disk was a common cause of severe

sciatic pain. In addition they called attention to the true nature of the "chondromas" and the role played by the nucleus pulposus in these lesions Prior to this important contribution the diagnosis of ruptured intervertebral disk could be made only at operation More over the lesion usually was mistaken for a neoplasm Spines were explored only when the symptoms and findings were those of spinal cord tumor Mixter and Barr deserve the credit for calling attention to the presence of ruptured disks in many cases of severe back and sciatic pain with but meager neurologic findings. This new syndrome was discovered through the integration of the knowledge accumulated by several investigators Dandy claims that intervertebral disk protrusion has become the most frequent lesion encountered by neurosurgeons.

Iodized oil is a permanent deposit in the subarachnoid space (unless removed subsequently) and passes freely into the fluid-containing spaces in the cranial chamber It is a matter of serious concern, even though there is no absolute proof that it does actual harm Its presence is a good pretext for medicolegal action particularly if no disk is found at operation.

In 1937 Reichert first substituted air for iodized oil as a contrast medium and in 1939 reported thirty five cases with excellent diagnostic results Air shadows are by no means so striking as iodized oil shadows.

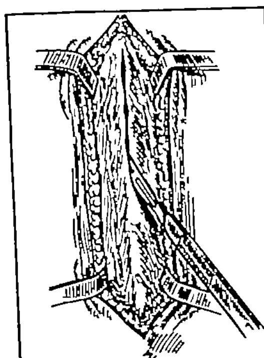
The next diagnostic advance was made by Semmes who reported sixteen cases that were diagnosed solely by history and neurologic examinations without any contrast medium whatever

Pathologic Changes in Disks Disk lesions include traumatic, degenerative and infectious conditions which have been described by Ghormley In a typical clinical case of ruptured intervertebral disk, a large part of the tumor is composed of nucleus pulposus. The presence of portions of the annulus fibrosus in this mass does not alter the fact that the presence of nucleus pulposus is the cardinal observation Bradford and Spurling refer to this entity as "rupture of the annulus fibrosus with posterolateral or posterior herniation of the nucleus pulposus" Other terms used are "rupture of the intervertebral disk" and "herniation of the nucleus pulposus," protrusion and extrusion.

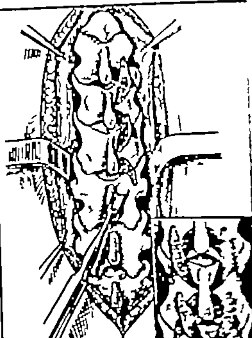
Concealed Disk Syndrome Dandy described a variation of the lesion which he called a "concealed disk." A concealed disk is one in which a forceps may drop into the substance of the disk through a small opening (A forceps cannot sink into a normal disk.) A *concealed disk is one that protrudes so* slightly that it can hardly be found at operation unless the subdural region is explored with great care Concealed disks make up more than twenty five per cent of the total cases Symptomatically there is no difference in the manifestations but at operation the detection of the lesion is more difficult. Furthermore, the most important reason for avoiding spinal contrast mediums is that a concealed disk does not show a filling defect

Mechanogenesis of Disk Lesions Intervertebral fibrocartilaginous disks protrude posteriorly into the spinal canal as the result of unusual stress or strain applied to the vertebral column The stress may be the result of a single outstanding injury or the result of repeated injuries of varying degrees of severity

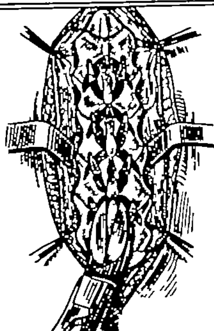
There has been considerable controversy concerning the mechanism of in



Exposure of spinous processes by incision through ligament and periosteum



Periosteum dissected from spinous processes and laminae. Ligamenta subflava and articulations curetted. Bone elevated from laminae



Spinous processes partially fractured and turned down to make contact



Periosteum and liga- interrupted sutures

Fig 6. The technic of Hibbs operation for spine L

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have
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jury. Some authors believe the disk is more apt to be protruded when the spine is in flexion and others think it is more vulnerable in extension. The discussion hinges around the relaxation or tautness of the posterior spinal ligament. There is no doubt that when the spine is flexed, the nucleus pulposus is driven backward but at the same time the posterior spinal ligament is stretched and made taut because the posterior space occupied by the intervertebral disk is increased.

Friberg believes that during life it should be assumed that the nucleus must degenerate before it ruptures unless the intervertebral disk has been subjected to unusual violence. He believes further that extremely strong pressure sufficient to enter the bony substance, is a prerequisite to protrusion of the annulus fibrosus. If the whole nucleus pulposus or a part thereof is loosened the detached portion alone protrudes. He makes the statement that the intervertebral disk in the intervertebral space exposed by operation was on the whole unchanged. That is, the space was not narrowed, despite the fact that operation had revealed perforation of the annulus fibrosus through to the nucleus pulposus and that large portions of the latter had been removed.

Several years ago Schmorl connected some of the disturbances of the intervertebral disk with the insertion of the posterior longitudinal spinal ligament. This ligament adheres to the vertebral body by only a few thin fibers, while its main fibers adhere to the intervertebral disk. It spans like a bridge the slightly retracted posterior surfaces of the vertebrae. Owing to this, no abnormal traction can act on the ligament and no abnormal ossification can occur. Larger ossifications protruding into the front of the vertebral canal are seen in the lateral roentgenograms as posterior spurs. Schmorl's nodules (herniated disk tissue) originate in the intervertebral disks. In addition, ossifications of the ligamenta flava or marginal dents of the smaller vertebral joints may protrude from behind into the vertebral canal.

Signs and Symptoms. Not all disk prolapses produce symptoms of sciatica nor are all sciatic troubles due to disk protrusions. The commonest symptoms and signs and those which are of the greatest value in arriving at a clinical diagnosis of protrusion of a lumbar disk are unilateral sciatic pain, which occurred in seventy-eight per cent of Love's cases, and bilateral sciatic pain present in sixteen per cent. In the other six per cent, backache alone or extension of pain elsewhere than along the course of the sciatic nerve occurred. Pain which interfered with sleep at night was complained of by twenty four per cent of the patients. This is an important symptom when present. It is particularly suggestive of a lesion of a nerve root but it is much commoner in cases of intraspinal neoplasm than in cases of protruded disk. Another indication of involvement of a nerve root or of a radicular type of pain is accentuation of the pain on coughing, sneezing, or straining at stool. Such accentuation occurred in sixty four per cent of Love's cases. Paresthesias in the dermatome supplied by the compressed nerve root are of value in the diagnosis and localization of the protrusion. Paresthesias occurred in fifty per cent of Love's cases. On the other hand, sphincteric disturbance occurred in only four per cent.

One characteristic of the course of

the intervertebral disk syndrome is its variability which is characterized by intermittence of symptoms.

I had one patient who found that by punching his right buttock he was able to reproduce his pain on the right side whereas punching his left buttock caused no pain He had a right-sided protrusion of the fourth lumbar disk This is the reverse of the Queckenstedt test. It is a test that is worthy of performance but should not be given too much prominence If it is positive it is confirmatory evidence.

I have been able to localize many lesions by giving the patient a pinch of snuff to cause a sneeze or two which exaggerates his pain

In an analysis of 500 consecutive cases in which operation was performed for protrusion of one or more intervertebral disks Love and Walsh found that fifty-eight per cent of the patients gave a history of a specific injury to the back. Analysis of their series of cases reemphasizes the point to which Love and Walsh have called attention previously that a high percentage of patients give a history of intermittency of symptoms Eighty-four per cent of their 500 patients had intermittent symptoms Whether this intermittency is due to vascular changes in the protruded portion of the disk, as suggested by Deucher and Love or to degeneration and interruption of pain fibers as a result of compression of the nerve root by the protruded body as suggested by Adson or to a return of the protruded fragments to within the center of the intervertebral space is not known. Intermittency is a characteristic finding and serves as a useful criterion in distinguishing between root pain caused by a protruded disk and that caused by an intraspinal neoplasm which usually is characterized by definite progression of symptoms and signs without remissions

All of Verbrugghen's patients operated on had sciatica seventy five per cent had low back pain ninety per cent had intermittent symptoms only sixty two per cent had a history of trauma eighty per cent, however had pain on coughing and sneezing and sixty five per cent had various kinds of numbness and tingling in the outer border of the leg and foot The commonest finding was a positive Lasègue sign which occurred in eighty two per cent and was associated with a tender spine in eighty two per cent of the cases There was some interference with the ankle jerk on the affected side in seventy-seven per cent, changes in sensation in the foot and leg were observed in seventy per cent, and roentgenologic changes observed in about twenty five per cent. Changes in the spinal fluid were noted in fifty cases of which forty five had a total protein of over 40 mg From the study of the spinal fluid alone, one was able to say that a good result could be anticipated if there were raised total protein Contrast media were used in the beginning (lipiodol) but later air was substituted. Now air is used exclusively but only in atypical cases to confirm the diagnosis

From the large number of patients with varying degrees of back and sciatic pain, a small proportion have both back pain and pain throughout the sciatic distribution The pain is intractable to conservative measures and there have often been previous attacks There are *definite but often inconspicuous* neurologic findings

Mild cases of herniated nucleus pulposus are more prone to remissions

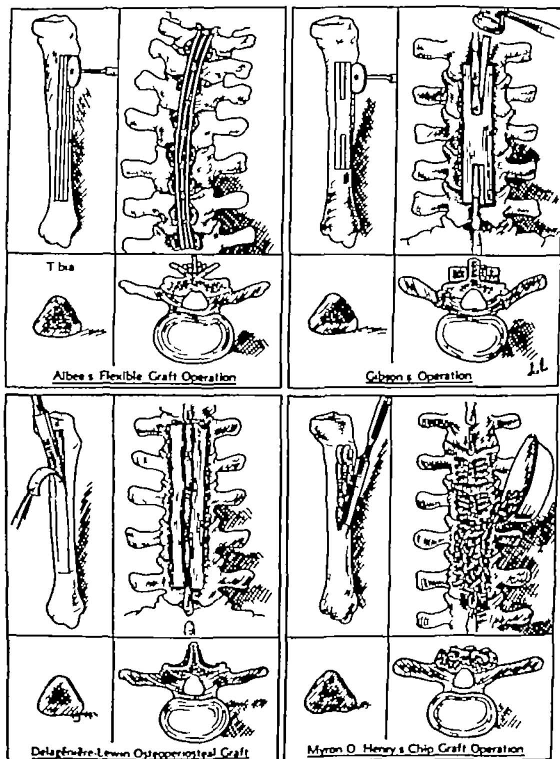


FIG. 7 Various types of standard operations on the vertebrae.

and therefore may not call for surgical treatment The surgical treatment of herniated nucleus pulposus is fundamentally a procedure to relieve pain

In spite of the fact that many patients with severe persistent sciatic and back pain recover spontaneously without the aid of surgery there is a large group who improve but do not fully recover In 1906 Camus and Sezary reported a case which from the history and findings was in all probability due to herniation of the nucleus pulposus Seeing the same person in 1911 Dejerine said, "Son etat est toujours le meme" Many patients who have suffered, year after year from intractable sciatic pain without showing evidence of a progressive lesion probably have had ruptured intervertebral disks with herniation of one or more nuclei pulposi

Since the herniated nuclei pulposi compress the spinal nerves near their only exits from the spinal canal, it is logical for the radicular neurologic findings to localize the lesion. The predominance of these lesions at the fourth lumbar and lumbosacral disks simplifies the problem of localization If only those patients who are incapacitated by involvement of the components of the sciatic nerve are selected for operation relief of symptoms can be promised uniformly Recurrence of the pain and disability after the patient has resumed active labor is a real possibility

No lesion can assume much size in the cervical or thoracic regions of the spinal canal without interrupting some nerve pathway and thus calling attention to a compressive lesion. In the lumbar region however a mass may be fairly large before any conduction system is affected. Friberg made the experimental observation that herniations up to 8 by 8 by 8 mm may lie lateral to the dura and nerve root without producing a demonstrable filling defect in the myelogram

Localization of Intervertebral Disk Disturbances Protrusion of any intervertebral disk may occur but in the vast majority of cases the displacement occurs in the lumbar region of the spinal canal Approximately ninety-six per cent of Love and Walsh s 500 patients had lumbar protrusions There is a very high incidence of protruding disks at the fourth and fifth lumbar interspaces ninety six per cent of all the lesions are found at the fourth and fifth lumbar disks and they are fairly evenly divided Protrusions in the cervical and thoracic regions of the spinal canal, because of the limited space between the spinal cord and the bony canal, resemble more closely intraspinal neoplasms Usually they are detected more promptly than those in the lumbar region, where the cauda equina has more freedom of movement.

In 1919 Dandy introduced air into the spinal canal. In 1922 Sicard and Forestier introduced lipiodol into the spinal canal Chamberlain employed oxygen or air myelography Spurling introduced pantopaque, which is immediately removed by aspiration

Diagnosis The most important diagnostic question is "Are we dealing with a disk syndrome?" The second question is, "Where is the trouble located?"

The diagnosis of a ruptured disk and its location usually can be made solely by the history and examination, and by so doing one relieves the patient of discomfort and possible after-effects Not even a lumbar puncture is always necessary

Our present concept of this syndrome

was established through the evolution and utilization of the knowledge accumulated by many neurologists neurosurgeons and orthopedic surgeons

If a person is awakened from sleep by pain in his back which is improved by change of position, it indicates a mechanogenic lesion, and the diagnostician has presumptive evidence of a space-occupying lesion in the spinal canal The pinch test is performed by strongly pinching the skin and comparing the sensation with that following stroking with cotton Some authorities run a hypodermic needle through the anesthetic skin Others run a safety pin through the skin and clasp it in position This impresses the patient very strongly Occlusion of both jugular veins until the face is flushed and the head feels full aggravates the pain in the leg and the paresthesia (Naffziger) Lewin proposed the artificial fever test. Hyperpyrexia will not help a disk syndrome but will strikingly improve a comparable pain due to arthritis fibrositis or muscle spasm

Since over ninety-six per cent of all protruded lumbar vertebral disks are at the fourth and fifth lumbar spaces and since the unilateral approach is adequate to find the lesion whether it is at the fourth or fifth disk it remains only to make the diagnosis of a protruded lumbar vertebral disk in order to disclose its location and remove it

How can the diagnosis of a ruptured vertebral disk at the fourth and fifth lumbar interspaces be made with assurance? The diagnosis is made on low midline lumbar backache plus pain down the back of one or both legs, the pain is intensified by coughing and sneezing and the pain must be recurring and not continuous There may or may not be diminution of the Achilles tendon reflex or sensory or motor loss in the distribution of the fourth or fifth lumbar or first sacral nerves.

An overwhelming percentage of protruded vertebral disks can be diagnosed and localized by the history and examination alone, and all accessory diagnostic tests can and should be avoided wherever possible

In cases of protrusion of a disk at the third lumbar level, the pain will be localized to the front of the thigh instead of the back of the leg

The three neurologic signs which are most helpful in the diagnosis of protrusion of a lumbar disk are Lasègue's sign sciatic nerve tenderness and diminution or absence of the Achilles tendon reflex on the side of the pain

Mixter and Barr deserve the credit for calling attention to the presence of ruptured disks in so many cases of severe back and sciatic pain with but meager neurologic findings. The diagnosis may be suspicious presumptive probable or positive The percentage of error in diagnosis of the presence of a protruded intervertebral disk and its location should be very small in experienced hands. Usually it is more harmful to withhold than to perform an operation

Dandy claimed that the diagnosis of a ruptured disk could be made solely from the patient's story of low backache *plus* sciatica, occurring in attacks usually after a relatively trivial injury such as a lift, bend, or strain Since the diagnosis can be made with accuracy by the clinical symptoms alone lumbar punctures, injection of contrast mediums into the spine are unnecessary

Symptoms are sufficiently different (usually pain in the front of the leg or diminution of the patellar reflex) to

suspect a lesion at a level higher than the usual one.

With the characteristic pain in the lower lumbar region and down the hip and back of one or both legs, the affected disk therefore is nearly always at the fourth or fifth lumbar, and it has been necessary to explore only one or both of these disks. Frequently there is a clue, such as a reduced or absent Achilles tendon reflex, which points to the fifth, although it may also exist with one at the fourth.

If the diagnosis is questionable, an exploration of the region is preferable to spinal injections of air or iodized oil.

Differential Diagnosis: There are only three or four other lesions that can give symptoms of backache and attacks of sciatica fairly similar to those caused by a protruded disk. (1) Tumors of the cauda equina, (2) congenitally defective fifth lumbar vertebra with destruction of the articular processes, and (3) spondylolisthesis. All of these are relatively uncommon. The last two can be differentiated by the roentgenogram. Spinal tumors usually will give some sensory or motor disturbances in addition.

Prognosis. The prognosis of disk injuries under conservative management is always uncertain because of the probability of recurrent attacks of backache accompanied by sciatic radiation pain. The outlook following an accurate diagnosis in uncomplicated cases, and an early appropriate operation, is excellent. The results depend to a considerable degree on the question of compensation and litigation.



FIG. 8 Support for lower back and abdomen. Note—Insert four V-shaped sections of heavy elastic webbing over each groin and over each costal margin.

Many cases of sciatica present a characteristic syndrome which can be relieved by surgery. The disk syndrome accounts for an overwhelming percentage of the "heretofore incurable and untreatable" low back pains and sciaticas, sacroiliac strains and arthritis of the spine.

Treatment should not be started until after a complete history has been taken, and physical, neurologic, and roentgenologic examinations have been per-

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formed. Even when the tentative diagnosis of posterolateral herniation of the nucleus pulposus has been made nonsurgical treatment should be tried

I have seen practically all gross symptoms completely disappear under conservative treatment. Also I have seen the Achilles and patellar reflexes return during the course of conservative treatment But every one of these patients had definite "hangover" symptoms and would have been better off if he had been treated surgically

The situation is remarkably analogous to that which obtains in cases of internal derangements of the knee joint where locking, limp pain and limited movement disappear but the knee remains vulnerable to moderate stresses and strains and precludes athletics and combatant military service

Previous objections to the treatment of these cases were the use of lipiodol which was irritating and was objectionable to industrial commissions and laminectomy which might weaken the back. Now that these two objections have been overcome the back is not weakened and the patient's stay in the hospital is strikingly reduced.

Many writers advise spinal fusion following removal of a ruptured disk some almost routinely others largely in industrial cases, in which heavy work must be resumed Where compensation is a factor a fusion will not diminish the complaints and in cases with hard labor ahead, a rest of three months is probably adequate protection

At the Mayo Clinic the neurosurgical staff has operated for protruded intervertebral disks in more than 1600 cases By means of detailed studies of these cases, the neurologists orthopedists, roentgenologists, and neurosurgeons have come to recognize a protruded disk syndrome, and the accuracy of diagnosis, which is founded on the history and clinical and roentgenologic findings, is extremely high. The therapy likewise, gives excellent results with a mortality rate in surgical cases of less than 0.25 per cent

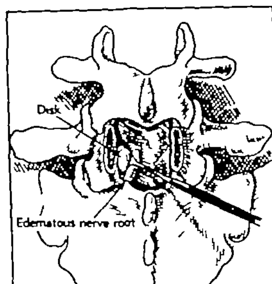
TREATMENT OF THE DISK SYNDROME

The treatment of the disk syndrome includes the nonoperative operative and postoperative measures

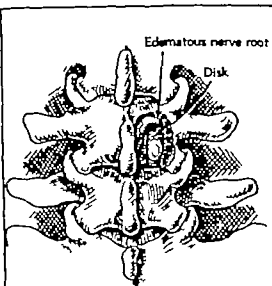
Conservative Treatment. Love and Walsh urge a trial period of conservative treatment, unless there is gross evidence of damage to the central nervous system before undertaking surgery for the relief of pain in the neck shoulders, back, or lower extremities. A period of observation and conservative treatment usually will indicate whether there is an underlying lesion of the spinal cord or of a nerve root which must be relieved surgically

Operative Treatment Three important advances have improved and greatly simplified the operative treatment Originally a bilateral laminectomy was performed and the disk was removed intradurally Mixter and Barr removed the disks extradurally by the bilateral approach Semmes and also Love in 1939 reported their removal by hemilaminectomy and by removing only a notch of bone from a lamina Love in 1940 removed a high percentage of ruptured disks through the interlaminal space without removing any bone His technic is the acme of perfection but can be accomplished only when the space between the laminae is of sufficient size Love introduced his precision operative technic of exposing and removing many disks without sacrificing any bone

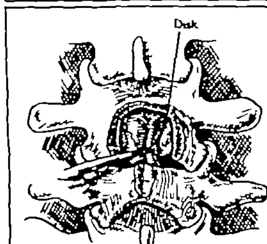
PRECISION AIDS IN LOCALIZATION



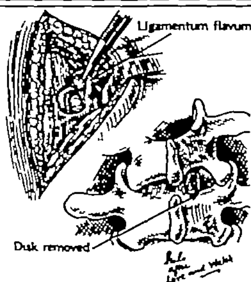
Exposure of protruded intervertebral disk by removal of one spinous process and one pair of laminae



Protruded intervertebral disk exposed by hemilaminectomy preserving spinous process



Protruded intervertebral disk exposed by partial laminectomy No neural arch is completely interrupted



Removal of intervertebral disk without removal of any bone. Upper figure shows resection of hypertrophied ligamentum flavum

FIG. 9 Operative procedure for removal of protruded portion of an intervertebral disk by the technic of Love.

There are precision tests in localizing troublesome intervertebral disks and determining the specific vertebrae involved. These should be reviewed in every case the day before operation. In addition, on the day before operation 1 cc. of methylene blue should be injected into the skin at the level of fourth lumbar *intervertebral disk and expose a lateral* roentgen film. The films should be in the illuminated box in the operating room during the operation. This marker is of great aid in localization during the operation.

ANESTHESIA. Many surgeons prefer local anesthesia for the preliminary stages of the operation. When the affected spinal nerve is located and the offending disk is discovered, a change is made to a general anesthetic, usually a gas anesthetic, only for the highly technical part of the operation.

The control of hemorrhage is accomplished by adrenalin in the local anesthetic, sponges of various sizes and shapes, electrical coagulation, silver clips and small pieces of muscle (like postage stamps) under pressure sponges. Mechanical aspirators are indispensable in maintaining an unobstructed dry field. Lewin uses the two aspirator retractor method to visualize the affected spinal nerve and the offending disk.

DISK OPERATIONS. There have been significant refinements in technic which permit more rapid operating with less *hemorrhage, less shock, and greater success.* Efficient retraction is indispensable. Adequate deep illumination is imperative. Love's dura retractor and nerve retractor are very helpful.

An intravenous infusion of dextrose in normal saline should be started as soon as the incision is made. Compatible blood should be at hand for immediate instillation if circumstances demand.

Just before operation make a short cross incision through the skin at the level of the interspace to be explored. If a long incision is to be made several superficial scratch cuts can be made to be matched up when the incision is *finally sutured.*

Suture towels to skin edges.

LOVE'S OPERATIVE TECHNIC. The anesthetic of choice is ether, which is best administered by the open drop method over the end of a Magill intratracheal tube introduced after the patient has been anesthetized by nitrous oxide and oxygen. The patient is then placed on the operating table as for any laminectomy. (Love performs his cervical laminectomies with the patient in the upright position, but operations on the other regions are performed with *the patient prone, the torso being supported* by two rolled pillows so that there is no interference with breathing.) When the lesion is low in the lumbar region or at the lumbosacral space a large soft, flat pillow is placed across the lower ends of the rolled pillows and between the symphysis pubis and the xiphoid process in order to increase the prominence of the lumbar spinous processes. This facilitates exposure in the lumbar region where the muscles are large and the distance from the skin to the anterior surface of the dura mater or disk, is greater than at any other level of the spine.

Subperiosteal exposure of the spinous processes and laminae of the two vertebrae between which the protrusion has occurred, furnishes adequate exposure for removal of the disk. (The author has designed a special instrument for spreading apart the laminae to facilitate

removal of protruded intervertebral disks in those cases where the operation can be performed without removing any bone.) Occasionally the laminectomy necessarily is more extensive but often only a portion of the lamina of one of the vertebrae needs to be removed. If the protrusion is lateral it may be necessary to remove the articulating facets on that side in order to secure adequate decompression of the involved nerve root. Whenever possible laminectomy should be narrow and the facets should be preserved. This maintains normal stability of the spinal column following operation. In the cervical and thoracic regions wide laminectomy at least on one side, is the rule, for here the spinal cord must be rotated in order to obtain satisfactory exposure. Section of one or more teeth of the dentate ligament facilitates rotation of the cord.

Unilateral protrusions in the cervical region can be removed by hemilaminectomy. This is always preferable when one is dealing with intraspinal lesions in the cervical region, because the neck is left in a more nearly normal condition after operation. In spite of the free motion of the cervical spine, there is little or no danger of dislocation—a condition which does occur although rarely *following* bilateral cervical laminectomy.

The protruded disk may be removed extradurally or transdurally. The operation should be adapted to the particular case after exposure has been made. If the protrusion has occurred to one side Love prefers extradural removal. If the protrusion is in the midline and particularly if the extruded mass is small, transdural removal is easier and is accompanied by less bleeding. If the dura is retracted for an anterior extradural approach to a small herniation of the disk, bleeding from the extradural vessels is likely to be profuse and very troublesome. Love finds that the extradural veins are either thrombosed or sufficiently displaced by the larger protrusions so that they are not injured during the removal of the mass and consequently the hemorrhage is less

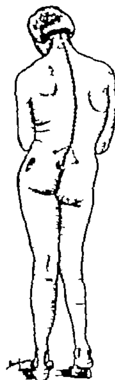


FIG. 10 This seventeen year old girl had poliomyelitis when she was two years old. Because of the flail right knee, with involvement of all groups of muscles, tendon transplantation was not possible, and an arthrodesis was performed. When she stood on both feet, there was a total right scoliosis; the right *gluteal* crease was 5 cm. (2 inches) lower than the left, the dimple at the posterior superior iliac spine was lower on the right, the right iliac crest and anterior-superior spine were low, there were three folds in the left iliocostal angle and none in the right. When wood splints were placed under the right foot until it was raised 5 cm. (2 inches) the pelvis was level and the scoliosis corrected. (Drawn from photograph) (Note: A leg shortening operation was advised.)

Some of the protrusions are of bony hardness while others are soft and fluctuant. Fluctuant masses should be aspirated with a small needle to exclude the possibility of pus in a tuberculous lesion before the mass is incised, for to incise such a lesion in the presence of an open dura mater is fatal

From the point of view of surgical anatomy protrusions are of two kinds (1) Those that pop out when the dura mater is retracted and the thinned out posterior longitudinal ligament is incised and (2) those that are firmly adherent to the adjacent vertebrae and require sharp dissection for their removal.

At operation the protruded disk usually resembles a bald head or the little ball that is spun on a roulette wheel. The extruded portion of a protruded disk may look like a round yellow pea. The nerve is sandwiched between two firm objects. The mechanics of the relation of a protruded intervertebral disk and the spinal nerve indicates that the squeeze is being carried out by the protruded disk compressing the nerve against the dura, the ligamentum flavum or bone

Some authorities advise vigorous curettage of the disk Others recommend scraping vertebral spurs and posterior vertebral margins I look upon the latter procedure as potentially harmful because it is analogous to removal of spurs from the os calcis which stimulates local osteogenesis

Love keeps his patients in bed for from twelve to fourteen days following operation, during which time they rest on soft pillows so arranged as to keep the spine straight. They are turned every four hours The skin sutures either silk or dermal, are removed on the tenth postoperative day Catheterization is performed every eight hours if the patient is unable to void. If voluntary urination does not occur by the third day an indwelling urethral catheter is inserted for continuous drainage of the bladder until the patient is out of bed The indwelling catheter and the bladder are irrigated twice daily with a four per cent solution of boric acid and 0 48 Gm (7½ grains) of methanamine and 1 Gm (15 grains) of ammonium chloride are given by mouth three times daily Love believes this routine minimizes the danger of cystitis and infections of the urinary tract. The catheter is removed after five days and is replaced by another sterile catheter

A common occurrence during operation is the sudden jumping of a thigh or leg when a lumbar spinal nerve is compressed during the operation It is a very valuable danger signal

After the Operation There are several "stunts" used by various surgeons in the postoperative care of these patients These include the split mattress, the Herzmark frame, and the Stryker frame. Others use no special apparatus but place the patient on his side on an ordinary mattress The nursing care of the uncomplicated case is very simple amounting to routine nursing care of all back patients

The Question of Combined Operation Removal of Disk and Fusion When should fusion be used as a supplement to the removal of a protruded or concealed intervertebral disk? The neurologist leans far away from fusion The orthopedic surgeon in general leans closely toward fusion. There are a few however who take a middle ground, these being the men who work in teams of neurosurgeons and orthopedic surgeons. Past experience with cases of chronic backache compels the

orthopedic surgeon to be very cautious in advising against fusion. So many of these back cases are chronic and removal of a disk no matter how perfectly leaves the person with a chronic, weak, inefficient, insufficient spine It is unreasonable to expect the removal of the protruded disk alone to correct the back trouble



FIG. 11 Method of applying body cast in Sayre suspension apparatus. Correction is obtained by head traction plus corrective lateral deviation brought about by adjusting the patient's arms on the uprights.

The question of whether the fusion operation should be performed at the same time as the removal of the disk is important. I believe that most of the fusion operations should be done at a subsequent time rather than at the time the protruded disk operation is performed. If there are congenital anomalies and a long history of chronic back trouble and the person is to return to heavy duty a spine fusion should supplement the exploratory operation.

The cases in which Macey employs the combined procedure of hemilaminectomy removal of the disk and bone grafting, include such conditions as spondylolisthesis, separated neural arch without slipping of the vertebral body and marked narrowing of the intervertebral space with hypertrophic arthritic changes At this point let me emphasize the importance of the intervertebral foramen and the articular facets which if destroyed or weakened will lay the groundwork for future mechanical trouble of serious degree

The static type of back trouble and the chronic type of back trouble require a fusion operation The history of the case, the physical examination, the roentgen-ray findings and the occupation, determine whether a fusion should be performed. Each surgeon must decide for himself whether the combined operation should be done at one time or in two separate stages If it is to be done in two stages the patient should be told before the first operation that a second one should be performed later

The number of combined operations performed has increased during the years In the year 1936 no combined operations were performed at the Mayo Clinic in cases of suspected protrusion of an intervertebral disk. In 1937 one per cent of the patients for whom laminectomy was performed also underwent a bone graft operation. In 1938 6.5 per cent, in 1939 14 8 per cent, and in 1940 fourteen per cent of the cases in which laminectomy was performed for suspected protrusion of an intervertebral disk, had bone grafting The increase in this percentage is due not only to the fact that both neurosurgeon and orthopedic surgeon felt that some patients with protruded disk should undergo bone

grafting but also to the fact that in many cases in which the orthopedic surgeon had planned a bone grafting operation he asked that the neurosurgeon perform laminectomy so that it could be determined whether or not a protruded disk might be present In the latter group they particularly refer to cases of spondylolisthesis spondylolysis and the like

It was their opinion that the surgeon could promise relief to the majority of patients with protruded intervertebral disks by removal of the protrusion alone But it was also their opinion that there was a group of cases in which bone graft or fusion operation should be done to relieve most of the symptoms and to give the best result.

It must be borne in mind that the roentgenographic appearance alone is not the determining factor in cases in which combined operations are chosen A careful review of the patient s history must be carried out and the symptoms must be analyzed Patients who have a long-standing static type of backache and who have evidence of a superimposed protruded disk whose pain is not relieved by rest, may be advised to undergo the combined operation.

In those cases where a combined operation is to be performed it should be done by two teams if they are available first, a neurosurgical team and second the orthopedic surgical team



FIG 12. Reversible camptocormia brought on by injury curved by lumbosacral fusion.

When a fusion is performed, the placement of the grafts is of great importance It is imperative that the grafts be in contact with bone Bilateral grafts *i e.*, one on each side, using heavy grafts is advisable If the grafts are not in contact with bone, hemorrhage will float them apart and failure of consolidation is almost inevitable It is important that a dry field be maintained because hemorrhage will jeopardize the fusion There must be no slipping of any of the bone



FIG. 13 Intervertebral disk with nucleus pulposus. Normal excursion of nucleus during flexion and extension of spine.

grafts because slipping will cause pressure on the dura and nerve pain. If the dura is opened and cerebrospinal fluid leaks out, it will "float" the grafts and jeopardize bone contact and subsequent fusion.

END-RESULT STUDY OF THE TREATMENT OF HERNIATED NUCLEUS PULPOSUS BY EXCISION WITH FUSION AND WITHOUT FUSION * From the material analyzed in this study it appears that, if 100 patients with herniated nucleus pulposus are subjected to disk excision, one may expect sixty of them to obtain long-term results which are satisfactory If the same 100 patients should have spine fusions in addition to the disk excisions the results will be satisfactory in seventy of them Sixty of these patients would not have needed the fusion operation, and of the forty whose results are unsatisfactory only ten could have expected sufficient improvement to make them satisfactory Furthermore the fusion procedure is an added operation, and there is no reason to believe that its effectiveness is greater if it is done at the time of the disk excision than if it is performed at a later date as a second-stage operation. The committee was therefore led to the conclusion that, when surgical intervention is necessary for simple cases of herniated nucleus pulposus the operation of choice is disk excision only Spine fusion can be performed at a later date in those patients whose poor results warrant additional surgery

* By the Research Committees of the American Orthopaedic Association, L Wm. Nachlas, M D., Chairman.

COMMENTARY ON THE DISK SYNDROME SITUATION The characteristic symptoms and signs that we were taught as indicating the presence of a spinal tumor are being taken over bodily in diagnosing a disk syndrome (except for the intermittency of symptoms in disk lesions)

Some orthopedic surgeons say "Wait till you see how many disk removal cases will need subsequent fusions"

Neurosurgeons say "If you only knew the number of fused spines that should have had disk removal first."

How many disk-operated persons return for fusion?

How many fusion-operated persons return for disk operation?

How many disk-operated persons return for fasciotomy?

The diagnosis of a disk syndrome is likely to become an escape for inadequate diagnosis

Compensation is a self perpetuating mechanism producing invalidism It is

the perpetuation of symptoms for unconscious purposes

A protracted disability enhances the original organic symptoms as a hysterical aftermath, used for escapist or other purposes.

Dandy claims that merely opening the traumatized disk effects the relief or cure.

sacroiliac manipulation, exposure and stretching of the sciatic nerve fasciotomies and myotomies

The dermatomes are very valuable in localizing an intraspinal lesion Lesions involving the fifth lumbar nerve disturb the sensation of the skin over the top of the great toe and a strip up the foot and leg. Lesions involving the first sac-

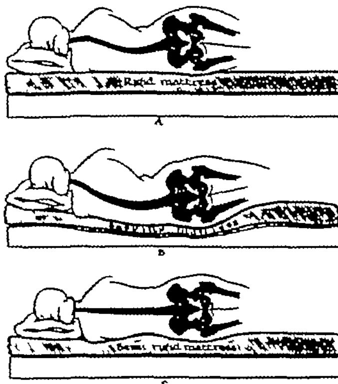


Fig. 14 A Rigid mattress causes curvature of the spine when the patient lies on her side due to elevation of pelvic and shoulder girdles. B Sagging mattress causes curvature of spine due to improper support of the heaviest portion of the body C Semirigid mattress supports all parts of the body properly

ral nerve disturb the sensation of the skin over the dorsum of the foot. Lesions involving the second sacral nerve affect the lateral aspect of the leg.

Nachlas correctly asks, "What component of the operation produces the relief?" He adds, "There has of course, been a moderate spine flexion under anesthesia. A stripping operation is necessary for the exposure The nerve root is frequently stretched by the retraction." He wonders if a disk operation does not carry with it some of the elements of such other procedures as

Lumbosacral Fusion by the Hibbs Technic As Described by Alan De Forest Smith The first requisite for any spine fusion operation is a painstaking, clean dissection of the ligaments, periosteum and muscles from the

bone This should be done with a minimum of bleeding and careful hemostasis without which an adequate exposure and effective treatment of the bone cannot be accomplished. If oozing is troublesome at any stage of the operation, the area should be packed with gauze and work carried on in another place while this part of the field dries up Without such an exposure any method is likely to fail.

In a lumbosacral fusion of the Hibbs type, a midline incision is made from the spinous process of the vertebra above the upper area of the fusion to the third sacral spine The dissection then includes the spine and a portion of the laminae but not the lateral articulations of the vertebra above the fusion area. This point is important because stripping of the ligaments from the lateral articulations of such a vertebra leads to scarring and damaging of the joints, which may be a source of pain (see Fig. 6)

The supra and interspinous ligaments with the periosteum are separated from the spines and laminae with a sharp elevator The use of a scalpel to split the ligaments and to start the dissection from the bone is helpful. Before stripping to any depth, it is best to expose the tips of several spines and to proceed in length as well as depth. Otherwise, exposure is difficult and the field cannot be visualized easily Before the upper arches are exposed completely the lumbosacral joint should be identified to keep from carrying the dissection too high The muscles are retracted and the capsular ligaments of the lateral articulations are detached with a chisel elevator and retracted laterally These ligaments are then incised at the outer sides of the joints and are removed with a curette If this is not done, they fall back over the facets or into the joint spaces.

Starting just medial to these joints the superficial portion of the ligamenta flava are then detached from the upper margins of the lower laminae and excised with a curette. The deeper layers of these ligaments should not be removed, however unless the intervertebral disks and nerve roots are to be explored

The next step is the removal of the cartilages from the articulations It is Smith s practice to detach the cartilage with an osteotome the blade of which is bent at an angle with the shaft so that it may be introduced more easily into the oblique or coronal joints common in this region. Very little or no bone should be removed in doing this because it is desirable not to make the space left by removal of the cartilage any wider than is necessary The cartilage then is removed with a curette There should be an assortment of these instruments, graduated from a very small one to a large size A bent or gooseneck curette is often essential to reach the depth of the joint. Thorough removal of the cartilage is difficult but most important. Usually a second curettement at an interval after the first, results in getting out cartilage that did not come away at the first attempt. After the cartilage has been *removed,* the space between the facets should be narrowed in some manner Smith formerly placed a small wafer or bone, from a spinous process in the space, but he believes that this *often delays* union Instead several cuts are made with a thin osteotome into the articular processes parallel with the joint surface so that these *thin slices* of bone separate slightly and fill the space It

is believed that the inclusion of the lateral articulations in the fusion is of great importance and that if they are not obliterated, the entire fusion is jeopardized.

It now is in order to bridge the spaces between the laminae and spines With a gouge several small pieces of bone are turned up from the fossa just below the articulation over the joint. Longer strips are then turned up from the lower lamina and down from the upper one so that they interlock. The number and size of such strips varies with the width of the laminae and the consistency of the bone It is best to keep these pieces of bone attached at their bases, not because it is believed that it preserves their blood supply and their vitality but because it prevents them from becoming displaced The spinous processes may be left intact, and the strips of bone are started from their tips It has been my experience that the tips are apt to break off and that strips of bone taken from the whole spine are too long I therefore cut off the tips of the spines split them into smaller pieces, and use them to reinforce the fusion

Usually an adequate amount of bone can be turned up from the sacrum If this bone will not suffice or if the fourth lumbar is to be added more bone may be placed on the bed already prepared The best source is the posterior part of the ilium The cancellous bone from this area is ideal and long strips cut from the crest and outer side of the ilium may be used to bridge the entire length of the fusion The ilium can be exposed by reflecting the skin from the incision already made but a better and easier exposure is gained by a separate curved incision over the posterior crest The bleeding from the ilium after removal of the grafts may be difficult to control and may call for the use of bone wax or oxycel gauze

If a bone bank is available the operation is shortened and nearly if not entirely as satisfactory results may be obtained by use of preserved bone Strips of ribs or pieces of cancellous bone from the ilium are the best

Several methods of employing metal for internal fixation have been used. They increase the stability of the spine during the early stages of repair after a fusion operation One of these is the placing of screws through the lateral articular processes as described by King and by von Lackum This produces excellent fixation of the fifth lumbar vertebra to the sacrum, where a long screw of from 32 to 38 mm. (1¼ to 1½ inches) in length can be made to penetrate the lateral mass of the sacrum and thus have a good purchase A drill is driven from the inner side of the upper facet downward and outward through the sacral facet and into the lateral mass The drill is then withdrawn and the screw introduced along its track It is Smith's practice to use screws in those cases in which the fifth lumbar is quite mobile and unstable. They are particularly helpful in spondylolisthesis in which the fifth lumbar arch is quite loose He does not use them when the fifth lumbar feels firm and is not easily movable nor in the higher lumbar joints In the latter the two articular processes offer so little fixation for the screw that one doubts its effectiveness

The operation is completed by approximating the tissues in layers with separate rows for the muscles deep fascia superficial fascia and skin Interrupted silk sutures result in the best healing.

Smith's present practice is to place

the patient immediately on a firm bed with a board under the mattress and not use any external support as long as he remains in bed. The modified Taylor brace, which formerly was applied immediately after the operation, caused great discomfort and afforded question able fixation for the spine The patient is turned as frequently as is necessary for his comfort and is taught to turn himself in bed as soon as he can do so Smith now allows his patients up from bed much sooner that we used to The usual time is at the end of the second week X rays are then taken, not with the expectation of demonstrating any fusion, but to show whether the bone chips and grafts are in position The patient walks as soon as he is able usu ally within a day or two after getting up and usually is ready to leave the hospital at the end of the third week after the operation. A study of the cases treated in this way shows that the results are better than in those who are kept in bed from six to twelve weeks This is equally true of cases of spondylolisthesis or of those in which the fourth lumbar vertebra was added for some other reason. Some form of os support is provided as soon as he gets out of bed. For women, this usually is a corset laced in front and with light steel stays behind Men use either a wide canvas lumbosacral belt with steel stays behind, or else a Knight brace. These supports are worn until x-rays demonstrate that the fusion is well advanced, usually for about four months. The patient s activities are restricted, and all bending, or lifting and carrying heavy objects are prohibited until it is felt that the fusion is strong Those who are engaged in sedentary occupations and who do not have to travel far to their work may sometimes return to a part-time schedule as early as six weeks postoperatively although this usually is not done until the end of the third month. Heavy manual work, sports, etc., are not permitted until at least six months have elapsed.

Under the best of conditions and with the greatest skill that can be exercised in doing these operations, there are some failures One must be constantly vigilant and always suspicious of a failure until it has been proved otherwise One of the commonest symptom of failure of fu sion is pain and fatigue

Philip D Wilson's Stabilization Technic The objectives in the use of metallic internal fixation in lumbosacral spinal fusion are as follows

(1) To provide absolute immobiliza tion of the operated area during the period of osseous repair (The plate does not supply material for fusion and is relied on only for temporary immobili zation bone healing here as elsewhere depends in large measure on immobilization bed rest, plaster spica, brace, or corset provide less certain fixation.)

(2) To shorten the period of post operative recumbency

(3) To reduce postoperative discom fort.

(4) To reduce the number of fusion failures

With these objectives the forerunner to this series of operations was per formed in 1939 In that patient a double-plate technic was employed, in which a special metallic spinal plate of fairly large size was placed on each side of the spinous processes of L4 L5 S1 and S2 and attached thereto with through and through bolts and nuts The spine fusion itself was a modification of the Hibbs method but with extra autogenous bone as well as osteoperiosteal graft from the tibia added Exploration

of this spine five years later proved this double-plate technic faulty The spinous processes were destroyed by the pressure occurring between the two plates A single plate has been employed in all subsequent operations In the first fifty-five operations in this series a modification of the Hibbs type of fusion has been employed. The facets were denuded of cartilage and packed with bone chips Interdigitating chips were turned upward and downward from the laminae and sacrum Additional bone chips were obtained from tibia or ilium The spinous processes, however were spared The plate in this group was placed on one side of the spinous processes and attached securely thereto with bolts and nuts one bolt inserted through each lumbar spinous process and two bolts attaching the plate to the spinous processes of the sacrum

In eight instances additional fixation of the facets by screws after the method of von Lackum and of King was employed

Experience with the operation has produced refinements in instruments and technic which have simplified the procedure and reduced the operating time. The plates which are of three sizes are now smaller than the original A subcutaneous bursa due to a prominent plate, which required plate removal in three instances early in the series is *now an unlikely complication*

The solid bone graft, either from the patient s ilium or from the bank is shaped and drilled by an assistant. Holes are made to match those selected on the plate for best stability of the bolts in the patient s spinous processes The holes in the graft are made larger than those of the plate to allow easy insertion of the bolt Plate and graft are applied to opposite sides of the spinous processes and held in place with uterine tenaculum forceps passed through the holes of the graft and plate These forceps start the holes in the spinous processes which are then completed with a right-angle awl. Insertion of the bolts in the narrow confines of the wound is facilitated by the use of the bolt holder which allows firm pressure along the axis of the bolt. After applying a washer on the bone-graft side the nut is started on the bolt with a small right angle socket wrench Standard nuts, used early in this series frequently loosened, even though applied double or locked with wire This problem was overcome with the cooperation of the Elastic Stop Nut Corporation, by the development of a surgical Elastic Stop Nut, employing a nylon insert rather than the fiber insert of the commercial nut These nuts allow secure fixation at any desired tension.

Metallic-plate fixation in lumbosacral spinal fusion is useful only if the sacral spinous processes are large enough to allow secure fixation by bolts Small sacral spinous processes may be occasionally utilized by counter-sinking the plate if the posterior sacral wall is of sufficient thickness. *In our experience* the sacral spinous processes are adequate in about seventy-five to eighty per cent of the ordinary low-back patients. The purpose of the plate is to provide temporary immobilization and is not to be trusted unless it is demonstrably secure at operation

Postoperative Management Compression dressings of elastoplast are employed. During the first twenty four hour period following operation the patient is allowed to lie on either side or in the prone position. The blood-soaked dressings are changed after twenty-four hours This appears to be an important

factor in avoiding decubiti. The head of the bed is elevated moderately when the patient is comfortable and desires it When there is difficulty in voiding, the patient is allowed to stand at the side of the bed from the first day on. At the eighth or ninth postoperative day the patient is allowed to sit on the side of the bed, and then out of bed in the adjustable office-type posture chair with arms A high Goldthwait brace with subclavicular padded horns is applied on approximately the tenth day Ambulation is then increased as comfort and strength permit. The brace support is continued for six months Patients are advised to limit their activities for from three to six months depending on the nature of their occupation. Simple postural exercises are started when the fusion is demonstrably solid.

In twenty-nine patients, or twenty nine per cent, there was failure in the overall series

Wilson and his associates described a method of lumbosacral spinal fusion employing metallic-plate internal fixation. It is the purpose of this plate to provide temporary immobilization during the period of osseous repair It has been stressed that the use of the plate does not obviate the need of a careful and complete osseous fusion technic. An end-result analysis of 101 patients has shown a failure rate of 10 8 per cent, as revealed by lateral roentgenograms made in flexion and extension Of the most recent forty-six patients on whom the operation has been modified by the addition of a solid bone graft applied opposite the plate there have been three failures or 6.5 per cent. These results have been compared with other series not employing internal fixation

Bosworth warns that his procedure is not to be undertaken lightly and should be accompanied by thorough evaluation of the patient preoperatively and extensive supportive treatment of the patient during operation. Transfusion and infusion should be used during the operation and postoperatively if necessary Good nursing care is essential if one is to minimize complications

Essentials The operation is carried out with the patient ventrally recumbent on a table which will flex at a point beneath the pelvis. Most of the operative work is carried out with the foot of the table lowered so that the extremities are dependent in order to open up the interspinal spaces posteriorly To separate the spinous processes still further the head of the table is lowered at the time of implantation of the cortical portion of the graft. Considerable flexion of the patient is essential at the time of placing the graft so that firm stability and fixation thereof may be maintained postoperatively should the patient inadvertently reassume a position of semiflexion

The basic conditions for which the operations were performed were spondylolisthesis, typical herniated low lumbar disk, laceration of disk with no posterior protrusion, lumbosacral strain, fractured lamina and facets cicatrix of previous exploration, arthritis of facets, and osteochondrosis

(1) One should use a routine technic with as meticulous a preparation for the placing of grafts as possible when doing lumbosacral fusions

(2) Arthrodese only L5 or L4 to the sacrum, if possible, waiting until a later date to add other segments above unless situation at time of first operation absolutely demands fixation of a greater number of segments

(3) Use autogenous iliac bone in-

stead of tibial bone throughout the procedure

SPONDYLOLISTHESIS. *Burns Method.* Burns described a method of pegging the bodies of the vertebrae from the front The abdomen is opened by a left paramedian incision with the patient in the Trendelenburg position The intestines are packed off and the anterior aspect of the fifth lumbar vertebra exposed by *incising the posterior parietal peri*toneum, and cleared by blunt dissection the left common iliac vein being retracted upwards and carefuly guarded. A hole is drilled almost vertically downwards through the body of the fifth lumbar vertebra and through it a tibial graft is driven with a punch Burns believes that the hammering entailed may produce a partial reduction or at any rate an improvement in the dislocation He believes it not unlikely that the graft may be absorbed since he thinks the intervertebral disk is not an ideal situation for a graft and in view of this, he suggests a steel pin.

Mercer's Method The patient is placed on his back and the table raised at its lower end to produce an exaggerated Trendelenburg position. A long mid line incision is made to just above the umbilicus The abdominaal contents are packed off from the area of operation and a self retaining retractor inserted The subluxated vertebra is now inspected and its relation to the iliac vessels ascertained The gap between the sacrum and the slipping vertebral body is exposed by dividing the posterior peritoneum over it, ligating some small veins and the middle sacral artery and freed of overlying fatty fibrous tissue with a gauze swab An osteotome is driven in an antero-posterior direction into the lower margin of the fifth lumbar vertebra, an eighth of an inch from *its lower edge and into the upper mar*gin of the sacrum, an eighth of an inch from its upper edge In this way a rectangular hole is produced after the pieces of bone and the intervertebral disk have been removed. Autogenous bone grafts are taken from the crest of the ilium to wedge into this gap Two pieces are taken since a single piece cannot be gotten broad enough to wedge in firmly The grafts are hammered tight into the gap between the sacrum and the fifth lumbar vertebra and further screwed into place to ensure *their retention. If* they are not screwed in it has been found that when the patient is lifted off the table the lumbosacral gap may be opened up and the wedges of bone spring out. To avoid this, in addition to screwing the grafts in, the operation is usually carried out with the patient in a posterior plaster shell The patient remains in the shell for four months and then lies free from restraint in bed for another month. Thereafter he is allowed up in a Goldthwait brace

HERBERT C FETT, M D AND HERBERT C FETT JR M D

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The Management of Acute Orthopedic Problems in Children

As this discussion deals only with the management of acute problems in children, the etiology symptoms prognosis, and diagnosis will not be included unless, in the opinion of the author there is an indication to do so to emphasize some point in the treatment of one of the clinical entities

Acute Osteomyelitis Early diagnosis is a very important factor in the treatment of this very serious and difficult problem A frequent error is to delay treatment until there is x ray evidence of bone infection. After the diagnosis has been established, careful evaluation of the little patient's general condition is required in order to arrive at a satisfactory plan of treatment. These patients are acutely ill from the toxemia and dehydration, and do not tolerate surgery well until the infection has been combatted with antibiotics, transfusions intravenous saline and glucose and any other supportive measures which may be indicated. Absolute rest in bed with the extremities supported by means of a bivalved plaster plus sedation and careful observation will aid considerably in the appraisal of this patient's ability to withstand the shock of surgery Frequently a simple incision in a presenting abscess will aid considerably in diminishing the toxicity but it has been definitely proven that immediate surgery for drainage of the medullary cavity may prove to be fatal.

Probably the most satisfactory forms of therapy can be listed as follows

1 Rest in bed with immobilization of the extremity in a bivalved cast.
2 Repeated small transfusions.
3 Intravenous glucose and saline
4 Antibiotics as indicated Following a blood culture
5 Aspiration of abscess
6 Drainage of abscess
7 Removal of bone and packing with petrolatum gauze, followed by the application of a plaster of paris cast.

The value of a plaster of paris cast postoperatively in these cases cannot be stressed too emphatically With plaster of paris immobilization, the extremity is placed at complete rest, and the pain is markedly diminished, thus aiding considerably in the improvement of the patient's general condition Further benefits consist of the prevention of deformities and the prevention of pathological fractures Pain and difficulty in movement of an extremity re



Fig. 1A

Fig. 1A to Fig. 1F are serial x rays of a patient with osteomyelitis of the humerus treated by the closed method. Fig. 1G shows the end results.



Fig. 1B



FIG. 1C



FIG. 1E

sult in unusual positions while at rest in bed, and produce deformities which subsequently are difficult to correct. These difficulties can be avoided by the judicious use of properly applied plaster of paris casts.

Acute Suppurative Arthritis: Children suffering from an acute suppurative joint are also very toxic, and should immediately be placed at rest in bed with the extremity either in traction or in a plaster shell or bivalved cast,

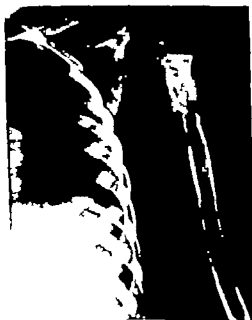


FIG. 1D



FIG. 1F



Fig 10

and the proper sedation prescribed Antibiotics may be started immediately but aspiration of the joint followed by *smear and culture will aid considerably* in initiating an intelligent regime for treatment The instillation of penicillin into the joint immediately after aspiration will be of value but the *sensitivity* of the organism should first be determined after which the properly selected antibiotic may be prescribed

Supportive treatment in the form of small frequent transfusions together with intravenous saline and glucose are very important adjuncts These measures are imperative because of the severe toxemia and dehydration which accompanies this pathological process

Surgical drainage of the joint is usually indicated when the patient's general condition is such, that in the opinion of the surgeon the shock of the anticipated surgery will be well tolerated Frequently repeated aspirations will demonstrate the fact that the pus is becoming somewhat thickened, and this is an indication for surgical drainage.

While every effort should be made to avoid destruction of the joint itself the main consideration should be to the life of the patient Therefore all forms of therapy must be directed toward this goal.

In the knee joint, as soon as a diagnosis of pyarthrosis has been established surgery is indicated Incisions *are made on both sides of the patella* in parallel longitudinal planes down through the synovia, according to the method of Willems The contents of the joint are thoroughly evacuated and irrigated with saline solution but no *drains should be inserted The wounds* are kept open by means of active and passive motion of the joint using extreme gentleness and care The postoperative care is most important because of the possibility of early closure of the wounds The cooperation of the patient is therefore quite necessary in order to avoid crippling of the joint.

Not only with regard to acute *suppurative arthritis, but also with regard* to acute hematogenous osteomyelitis it is imperative that antibiotic therapy not be instituted until after a blood culture specimen has been obtained in order to determine the exact etiology and the sensitivity of the invading organism to the common antibiotics A corollary to this fact is that *antibiotics should not* be withheld until the laboratory data has been obtained On the contrary an antibiotic effective against gram positive coccal organisms in particular to staphylococcus aureus should be immediately instituted

Acute Synovitis. This condition

may be either traumatic or infectious in origin, but the management of both types is quite similar

The patient should be placed at rest in bed with the extremity in traction and heat applied locally to the affected joint. If the temperature is not above 101 F (38.3°C) no antibiotics should be given, but the joint should be aspirated and the fluid sent to the laboratory for smear culture and sensitivity tests Antibiotics are then administered as indicated. Simple traumatic synovitis will probably subside quickly under this conservative type of therapy If the symptoms do not subside repeated aspirations will demonstrate the character of the fluid, and laboratory tests will give the surgeon information as to the progress of the pathological process The lesion may change from a serous type to a serofibrinous one, and occasionally to a purulent type of synovitis and arthritis

Meticulous care must be exerted in the aspiration of these joints to avoid the introduction of organisms during the course of the procedure. *Aspiration of a joint is not an office procedure*

Acute Hemophiliac Joints In hemophiliac patients, the clotting time is prolonged The platelet count is well within normal, as is the bleeding time The history in these cases is of paramount importance

The treatment of hemarthrosis associated with hemophilia, consists of rest in bed with the extremity in traction. As the knee joint is most frequently involved, a simple Bucks extension supplemented by slight elevation and the application of ice will usually result in relieving pain and discomfort. If the tension in the joint becomes excessive due to continued bleeding into the joint, aspiration may be indicated.



FIG. 2A. Roentgenogram of an infant with suppurative hip osteomyelitis, and luxation at the hip



FIG. 2B Same case as Fig. 2A showing findings by x-rays at postmortem.

This procedure however should be delayed as long as possible

Blood transfusions and injections of normal human plasma have been employed to control active bleeding

Recently some investigative work has been done with hiluronidase in the management of this very difficult syndrome and from all reports some *interesting and valuable data should* soon be available

Following the subsidence of an acute hemophiliac hemarthrosis efforts should be made to prevent the development of contractures with the resulting deformities by the use of proper splinting or bracing. The prognosis in these cases with reference to further bleeding into the joints must, of course be guarded as it is well-recognized that hemophilia cannot be cured

It has been our experience that the globulin fraction of plasma effectively and rapidly reduces the clotting time within two to four hours However the effect of this agent persists for a relatively short period of time i e., six to twelve hours In addition repeated use of plasma globulin fraction is not effective within the refractory period of twenty four hours On the contrary whole blood is the most effective single agent to reduce the clotting time In the event of emergency surgical procedures, and in the event whole blood is not available many satisfactory results can be obtained with the use of the plasma fraction

Acute Scurvy Occasionally it is the duty of the orthopedic surgeon to recognize a case of scurvy which has not been diagnosed by the attending physician The orthopedist is called upon because of the irritability of the child particularly when the extremities are moved or touched. Because of these clinical manifestations, the attending physician becomes *suspicious of the presence of* bone or joint lesion or possibly a paralytic condition The irritability of the child, the tender bones and joints *bleeding of the gums plus the x-ray* appearance of the bones makes the diagnosis quite easy The ground-glass appearance of the bone with evidences *of subperiosteal hemorrhage is* quite diagnostic

As this condition is due to lack of antiscorbutic vitamin C, the treatment consists of the administration of the vitamin, after which cure becomes apparent rather quickly Although some authorities believe splinting and massage are of some value most cases do well on the correction of the faulty diet

The guidance of a pediatrician is, of course quite essential in the management of this problem

Acute Bursitis Acute bursitis is not as frequently seen in children as in adults but if a clear-cut diagnosis should be made treatment should consist of local application of heat together with rest and support to the extremity It is also helpful at times to aspirate the bursa under the strictest of aseptic precautions After this a pressure bandage is applied It is seldom necessary to remove or incise the bursa in a joint, but occasionally this becomes necessary for biopsy

Acute Tenosynovitis. Acute tenosynovitis in a child is occasionally seen, and can be recognized by the fine crepitation which is present on movement plus localized tenderness along the course of the tendon

The treatment in these cases consists of rest plus the application of heat. The tendon should be relaxed perhaps applying light plaster-of paris cast to ac

complish this relaxation If the lesion is in the region of the Achilles tendon elevation of the heel should provide relief

Acute Achillobursitis When this diagnosis has been made treatment in the form of rest and heat is indicated. Occasionally these cases should be encased in plaster with the foot in equinus but usually the elevation of the heel on the shoe will suffice Any irritation in the region of the pathology should be removed. Cutting out of the back of the shoe frequently is necessary

Acute Apophysitis of the Heel This condition is usually seen in children between the ages of ten and fifteen years A clinical *diagnosis can be made* by the presence of complaints of pain in the region of the heel, plus localized point of tenderness. There may also be some clinical evidence of fullness in this region This condition may be quite incapacitating.

The treatment consists of rest and heat. The best form of rest is the application of a plaster-of-paris foot bandage, applied with the foot in very mild equinus, and a walking iron incorporated in the plaster

X-ray examination in these cases is a definite aid in confirming the clinical diagnosis Roentgenograms usually reveal some evidences of sclerosis of the apophysis together with fragmentation.

Aspiration of Joints As stated above the aspiration of a joint is not an office procedure because of the possibility of secondary infection as a result of poor technic. This procedure is of considerable value as it *diminishes* greatly the damage to a joint resulting either from trauma or infection. It should be carried out in traumatic cases within twenty-four hours posttrauma, but in cases due to infection, a lapse

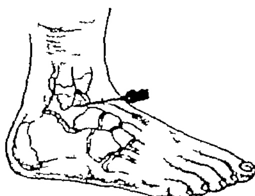


Fig 3 Aspiration of ankle joint.

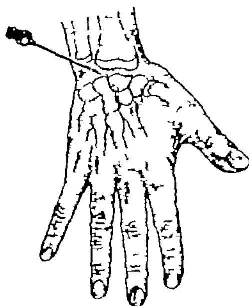


Fig. 4 Aspiration of wrist joint.

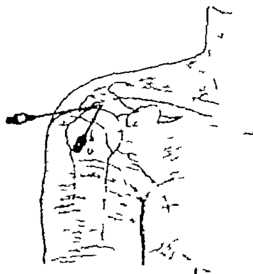


Fig. 5 Aspiration of shoulder joint.

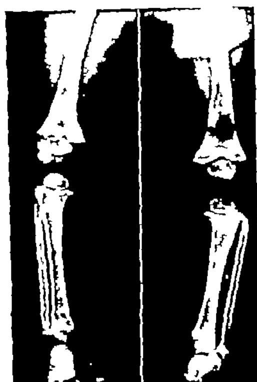


FIG. 9 Roentgenograms showing acute scurvy

draining the ankle joint, the J incision of Kocher is the best.

Shoulder The shoulder is best aspirated from either the anterior or the lateral approach. In draining the shoulder an anterior incision is made parallel to the deltoid fibers from a point 2.5 cm (1 inch) lateral to the coracoid process.

Elbow Aspiration of the elbow joint is best accomplished from the lateral aspect, inserting the needle in the region of the radiohumeral joint The joint can be drained best from both sides

Wrist The wrist is aspirated and drained from the dorsal aspect, avoiding the tendons as much as possible

It has not been the purpose of this article to discuss the treatment of acute fractures However we do feel that a few principles are worthy of mention

The treatment of fractures in children is not *similar to that in adults, for* very often, it is not in each case necessary to secure bony apposition to achieve an excellent functional end result. This fact has frequently been observed, particularly with regard to separation of the distal radial epiphysis,[1] fractures of both bones of the forearm and fractures of the shaft of the humerus and femur In fact, with regard to fractures of the femur in children a perfect anatomical reduction is not always imperative for such a reduction is very often associated with increased length of the femur due to osteogenetic stimulation at the fracture site Usually shaft fractures in children which demonstrate satisfactory alignment in one plane and bony apposition will produce excellent functional results

We are of the opinion that this information is particularly important when a surgeon, following inability to secure adequate reduction of shaft fractures in young children, elects to initiate surgical intervention which often is not necessary and which is often disastrous. A corollary to this fact is that fractures involving an epiphysis will usually require perfect reduction in order to prevent future growth disturbances.

[1] "Separation of the Distal Radial Epiphysis," Fett, H C., Medical Times, 1941

Read Before the 43rd Annual Meeting of the Associated Physicians of Long Island at St. Catherine's Hospital, Brooklyn, N Y., January 25 1941

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Acute Infections and Traumatic Injuries of the Hand*

Introduction The necessity for immediate and meticulous care of the injured hand so as to prevent infection and its well known sequelae is of crucial importance The national loss of working days caused by such injuries is greater than from any other type of casualty The tremendous importance of the hand in war and peace, in industry and in the general livelihood of the individual cannot be minimized. Since the advent of antibiotics hand injuries are rarely considered a menace to life however they do cause decided disability and inconvenience to the injured person as well as impose tremendous economic burdens on the community Hand injuries constitute thirty-six per cent of all industrial accidents

A complete knowledge of the anatomical structure and the basic function of the hand is basic to the institution of appropriate definitive therapy The intricacies of a well-balanced hand are manifested in its structure of muscles, tendons and joints, its complex motor and sensory nervous systems specialized neural endings, and its compact yet protective bursae, tendon sheaths and spaces.

Some textbooks continue to describe types of incisions which have been proven incompatible with the subsequent ease and proper functioning of the hand. A small injury or a small scar in the hand may impede or alter the use of both the hand and the fingers. A surgeon must think seriously of the placing of his incision since an incision placed incorrectly may involve the risk of future malfunction and possible deterioration of the hand. An incision must be made for adequate exposure and optimal drainage, yet so placed that subsequent scarring will cause a minimum of permanent injury Even the most innocent appearing wound of the hand or the fingers should be considered dangerous, or potentially so, for whenever the skin is broken a portal of entrance is made for infection.

Whenever possible, hemostasis should first be secured by the application of compression, or by a tourniquet proximal to the wound. The relatively bloodless field obtained by the latter procedure enables the surgeon meticulously to clamp and ligate blood vessels if this

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is deemed necessary without endangering other and perhaps more delicate or more important structures. Clamps should never be applied blindly or haphazardly The identification and establishment of the relationship of structures by meticulous examination and evaluation should precede definitive action. Care must be exerted in obtaining good hemostasis in order to avoid the formation of hematomas following closure of the wound. Hemorrhage and edema result in fibrosis which is capable of ultimately destroying many of the beneficial effects of surgery by freezing joints and tendons in essentially the same manner as inflammatory exudates

The use of wet soaks, either hot or cold, is now condemned in the therapy of the infected hand, either preoperatively or postoperatively since this procedure may compound the actual damage by causing swelling and maceration Drainage exits may be blocked or narrowed by tissues swollen by this mode of therapy A conservative attitude towards therapy of hand infections is safest.

INFECTIONS

In the treatment of the infected conditions of the hand, antibiotics are of great importance To increase resistance and to block the influences of the invading organisms prior to tissue necrosis—whether this be due to the primary invasion and infection or from ensuing edema, circulatory impairment, and devitalization—these agents should be employed as soon as possible after injury

If fibrosis has already occurred, it is of prime importance to immobilize the injured or infected hand by placing it in a normal position of function In addition to splintage, elevation is of importance Where obvious cellulitis is present, with its concomitant swelling, redness, and fever surgical intervention is delayed No surgery should be performed until there is fluctuation with definite formation and localization of purulent exudate Drainage is then accomplished by a small, well-placed incision, or incisions which will not later resolve in painful scars or cause malformation or disfiguration If a slough is present, it should be lifted out, if possible otherwise it should be left to detach itself at a later time If incision is necessary, and on proper indications through and through drains made of small gauze wick or preferably short lengths of soft, flat rubber may be inserted aseptically Dry compresses of either heat or cold may be used as needed. Superficial abrasions after cleansing, may be treated by applying a fine mesh gauze to the affected part with a copious dressing applied around it. To prevent later stiffness or fixation, finger motion should be encouraged as soon as possible The joints must be kept mobile and the fingers capable of flexion, extension, adduction, and abduction.

Skin Infections

Skin infections develop between the upper layers of the stratum corneum and may later involve the deeper tissues Generally skin infections develop secondarily to antecedent injury such as from superficial abrasions blisters cuts, entry of a foreign body or secondary to fungous infection Cutaneous infections are usually not very serious however they occasionally become so Later complications may include bacteremia septic endophlebitis, and lymphadenitis Beta hemolytic streptococcus, and *Staphylococcus aureus* are the usual pathogens found in cutaneous infections

MAJOR GENERAL WALLACE H GRAHAM, M.D , U S.A F

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Impetigo Impetigo is an acute infection which is contagious and autoinoculable This is a pyogenic infection of the superficial layers of the skin It is observed most frequently in infants and children The condition is characterized by the formation of vesicles bullae and pustules, which later become encrusted by a thick superficial layer of seropurulent exudate

Therapy Impetigo responds very well to topical therapy as the hemolytic streptococci are coagulase positive Staphylococci are most sensitive to bacitracin ointment 500 units per gram neomycin ointment 5 mg per gram aureomycin ointment and terramycin ointment 30 mg per gram, are also very effective Penicillin may be used however there is the risk of sensitization which is not prevalent with the other antibiotics In the event of chronic infection penicillin or aureomycin may be given systemically

Subepithelial Abscess

Subepithelial abscesses often follow penetration by a foreign body such as a splinter or a pin although an abrasion or blister may be the contributing cause. The infection may be localized or may extend completely around a finger Upon lifting the surface epithelium purulent exudate or an area of necrosis may be seen The basic epithelium may have scattered areas of tiny ulcerations and the surrounding base may be inflamed. Edema may or may not be present. This condition is treated by the immediate removal of all overlying blebs or necrotic epithelium The offending organism is usually a hemolytic *Staphylococcus aureus* which may extend from the wound to cause a generalized systemic infection A single dose of antistaphylococcic drug is usually adequate, but more prolonged therapy is necessary in the instance of invasive infection

Paronychia

A paronychium is a lesion in the marginal sulcus usually involving the lunular area. It may be acute subacute or chronic. Although it is primarily a pyogenic infection it may be superimposed on a chronic mycotic lesion It is frequently referred to as a "run around" since it follows the marginal sulcus of the nail and is usually painful with the pain being intensified by pressure on the nail This lesion may be opened and drained by gently pushing back the marginal sulcus and exposing the infected cavity If the lesion is lateral to the nail elevation of the cuticle with incision and drainage will be required The drain, if employed, may be made of silk nylon, or rubber wick and may be impregnated with 0 1 per cent bacitracin solution Systemic antibiotic therapy is reserved for spreading infection Fungous Infec

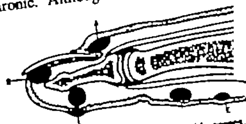


Fig 1 Types of Digital Abscesses. A. Paronychia, B. apical abscess, C pulp abscess with collar-button extension D subepithelial abscess E. epithelial abscess. (Modified from Bailey David M B The Lancet Jan. 26 195)

tion, if suspected, should be verified by culture and smear

Subungual Abscess

A subungual abscess may result from an extension of a paronychium or from the penetration of a foreign body The objective of treatment is to establish drainage by removal of a portion of the nail over the lesion If the abscess is extensive it may be necessary to remove the entire nail to prevent later osteomyelitis of the distal phalanx Topical applications of 0 1 per cent bacitracin solution or another appropriate antibiotic, will assist in eliminating the infection Parenteral antibiotics are unnecessary unless there is accompanying cellulitis or obvious danger of systemic involvement.

Pulp Abscess (Felon Whitlow)

Pulp abscess is the term chosen to distinguish a subcutaneous abscess in the pulp of the digital terminal segment. This abscess, with its surrounding inflammation, is in the firm, fibrous fatty pad between the periosteum and the skin on the lower surface of the terminal phalanx The offending organism is usually *Staphylococcus aureus* Early in the condition throbbing pain is felt and a localized cellulitis is present. The pulp space is tender and swollen, and lacks normal elasticity Pulp space infection may progress to a bony involvement or bony felon Diffuse osteoporosis in some instances, may be demonstrated in the terminal phalanx within five to eight days. Later if the process is left uncontrolled the swelling distention, and pulsation may decrease and the skin may change from inflammatory red to a dark gray or dusky color

A relatively localized infection may be transformed into a very serious condition if surgical intervention is attempted before there is demonstrable localization of the abscess Premature incision jeopardizes the normal resistance to infection in the noninvolved tissues, and may result in considerable damage to the essential local vascularity

Therapy· *Penicillin is the treatment* of choice in the early stages for infection caused by organisms susceptible to it 300 000 units should be given intramuscularly twice daily If the abscess is well formed and loculated, open drainage is indicated A small incision should be made over the lateral area of maximal tenderness in the diseased tissue only The necrotic tissue and purulent exudate are then evacuated. No attempt should be made to remove any strongly adherent necrotic tissue The wound should be examined to determine whether the bone has been involved in a felon-like process with the presence of bone sequestra.

Osteomyelitis of the bone as a complicating factor is not rare although it should be If bone is involved, the incision must be of the through-and through type to the skin of the opposite side, thereby severing all septa between the bone and the volar skin A fish mouth incision around the tip of the digit should never be performed, since the terminal normal tissue becomes involved in the infective process with excessive necrosis and terminates in a painful scar

Anesthesia Incision may be performed under local block anesthesia or under a short action general anesthetic, with a tourniquet applied about the base of the finger Intravenous sodium pentothal may be useful, but if the abscess is near the surface anesthesia may not be necessary

Apical Abscess

An apical abscess is usually the result of a pin prick or a foreign body under the nail In small, well-localized abscesses the removal of a V segment of the nail immediately over the abscessed area is all that is necessary If however the abscess is extensive it may necessitate the removal of the entire nail to prevent ensuing necrosis of the nail bed and possible osteomyelitis of the distal phalanx. Osteomyelitis is a rare complication of this condition, even though the abscess cavity may extend down to the periosteum

Osteomyelitis

Osteomyelitis is usually a secondary manifestation of injury or of foreign body penetration The diagnosis is usually made by slow response to therapy and is confirmed by observing the presence of bone involvement on roentgenographic study The digit should not be amputated merely because the bone appears to be involved. Treatment should consist of adequate drainage rest, immobilization, sterilization of the infected area, and by employment of appropriate antibiotics It is rare today to find osteomyelitis in the bones of the fingers secondary to tuberculosis or syphilis. Usually it is an infection of bone by extension from infected adjacent tissues, or by secondary infection resulting from compound injuries of the bone

In advanced infections bony involvement may be demonstrated by radiography In early infections, sequestration of minute pieces of dead bone may be noted extruding themselves in the drainage. If the bony fragment is detached or completely devitalized, they may be detected and removed on probing Sequestrectomy should not be performed until definite radiological evidence of a sequestrum has been established

The curet and chisel have no place in osteomyelitis which is secondary to soft tissue involvement. The organism may be determined through bacteriologic cultures, and the proper antibiotic administered accordingly Absolute immobilization of the part is essential during the acute phase however after the infection has subsided movement within the limitation of pain is encouraged With proper therapy this type of wound usually heals within five to eight weeks

The course of the infection depends upon the virulence of the invading organism In some patients, particularly in the elderly and in children, these organisms may be so active that within a few days radiographic examination will reveal complete disappearance of the bony phalanx In others the osseous erosion remains localized. Early therapy is therefore mandatory The extent of phalangeal re-formation depends upon the extent of the bone lesion and the age of the patient If there is complete destruction of the periosteum and osseous tissue regeneration will not occur When the destruction is partial the entire bony phalanx may regenerate in children and to a minor extent in adults

Web Infections (Collar Button Abscess)

Web infections which by exception may be diagnosed in the period of early cellulitis can be prevented if treated adequately and in time with the appropriate antibiotics

Web infections or abscesses are accompanied by obvious edema in the interdigital cleft which sometimes extends into the dorsum of the hand If abscess formation is present, the fingers, because of edema and extension of in



Fig 2. Web space infection with incorrect incision for drainage resulting in the severing of the volar arch at the bifurcation of the princeps followed by an arterial false aneurysm. Later a dense scar formed binding the involved fingers and limiting function.

fection, may have become separated. The abscess may be pointing in which case the location of the incision is obvious.

Therapy· After localization is manifest in the web space, the abscess may be opened through a small, shallow



Fig 3 Diagram showing correct lines of incision for web and thenar space infections which in neglected cases extend to the dorsum from the middle palmar space Note The web between the fingers is not severed, thereby obviating a binding scar (Modified from Kanavel Infections of the Hand, Lea and Febiger Phila., Pa., 1939)

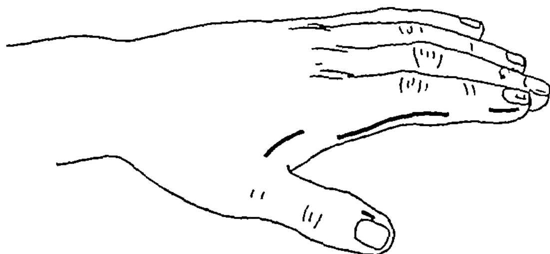


Fig. 3A. Lateral lines of incisions demonstrating selected avenues of exposure to the tendon sheath and thenar space.

transverse incision. Extreme care must be taken to insure against possible injury to the digital nerves If the point of fluctuation is anterior the incision should be made parallel to the skin crease and carried through the skin only The flexor tendon should be avoided for if its sheath is entered, a pathway for extension of the infection will be opened Necrotic tissue and purulent exudate should be removed and flushed away This area drains very readily and the insertion of a wick is usually not necessary In all web infections the patient should be kept in bed with the hand immobilized and elevated The hand should be splinted and the splint retained until all evidence of inflammatory edema has disappeared.

Carbuncles

Carbuncles are more commonly located on the dorsum of the fingers and hand than on the volar surfaces Adequate drainage excision if necessary and removal of necrotic exudate are among the therapeutic procedures to be followed. While some surgeons employ the installation of penicillin directly into the lesion, demonstrated resolution by adjunct antibiotic therapy systemically administered has led to preference of the latter regimen

Lymphangitis

Lymphangitis may be superficial or deep It may be a separate entity It may accompany an infection of the hand or it may contribute to the formation of an abscess in the deep tissues This condition is usually productive of marked edema, particularly on the dorsum of the hand Bright red streaks may emanate from the point of infection and course up the forearm and arm to the axillary lymphatic nodes If the infection is on the fourth or fifth finger the epitrochlear nodes are involved prior to the axillary nodes Lymphangitis, emanating from the thumb or the index finger will course to the dorsum of the hand, thence directly to the axillary nodes without involving the epitrochlear lymphatics The complications include cellulitis lymphadenitis and necrotizing ulcers along the lymph channels.

Therapy Since hemolytic streptococci are the usual cause of lymphangitis penicillin or one of the other antistreptococcal drugs are the treatment of choice In severe infections, or if the patient is old or debilitated, elevation and bed rest are advised Sedation and analgesic medication may be necessary Signs of systemic spread should be watched for and blood cultures should be taken if the temperature exceeds 101 F (38.3 C) If abscesses occur they should be opened and drained however incision of an abscess of acute tubular lymphangitis should never be considered, as the infection would thus be widely disseminated.

Reticular lymphangitis occurring in such superficial tissues as the skin is usually caused by streptococcal infection. It may however be secondary to involvement by staphylococcus gonococcus, or the anthrax bacillus The most severe forms are noted in erysipelas

Tuberculous lymphangitis is a chronic condition in which the lymphatics are firm nodular thickened and easily palpable As the disease progresses, the lymphatics degenerate and form abscesses which later develop into chronic ulcers. There is also involvement of the axillary and epitrochlear glands

Treatment consists of excision of the lesion with complete curettage Good results are obtained by the use of strep-

tomycin combined with para aminosalicylic acid in conjunction with the usual regimen for tuberculosis

Cellulitis

Cellulitis is an inflammatory infection of the deep cellular tissues to the skin and deeper levels in the interspersing connective tissues between the muscles It is frequently coexistent with lymphangitis Cellulitis usually originates from infected wounds or from sites of infection of the skin and subcutaneous tissues The process may cause lymphadenitis, bacteremia, abscess formation and tissue necrosis The tendency of this condition is to spread rapidly with resultant systemic manifestations of pain, general malaise and a temperature to exceed 101°F (38.3°C)

Therapy· The management of this condition is to place the hand at rest with elevation and treatment of the initial lesion Streptococci and staphylococci are the causative organisms Consequently penicillin in the aqueous preparation is administered intramuscularly the initial dose being 600 000 units followed by injections of 300 000 units of procaine penicillin every twelve hours If penicillin is contraindicated, any one of the broad-spectrum antibiotics may be administered 20 mg per kilogram of body weight given daily in four divided doses

Tenosynovitis

Tendon sheath infections have been the most dreaded and devastating of all inflammatory processes of the hand The provocative factor in this type of infection is almost always a gram positive coccus, such as staphylococcus or hemolytic streptococcus It is usually secondary to surface-breaking wounds which admit infectious organisms, or by contiguous involvement from a concomitant infection. The cardinal signs of this infection are manifested by (1) diffuse and symmetrical swelling of the entire finger (2) marked pain over the involved tendon (3) fixation of the finger and hand in the position of semi flexion and (4) excruciating tenderness on attempting to move the fingers either actively or passively In the acute phase, edema and cellulitis are present and later within the synovial membrane and around the tendon there may be purulent exudate

An excellent diagnostic procedure is to ask the patient actively to flex the involved member while the examiner places his thumbnail beneath the nail of the involved digit and his index finger on the dorsum and midjoint of the already partially flexed finger If tenosynovitis is present, there will be sharp pain along the palmar aspect of the finger as the patient tries to move the infected digit The pain is due to the bowstring-like contraction of the tendon against its sheath If the other soft parts alone are involved the pain is uniformly absent When infection enters the tendon sheath there is an immediate reaction by generalized effusion Swelling and tenderness are noted along the line of the involved sheath, and function is limited.

The synovium is next involved and becomes adherent at the initial point of the infection, thereby building up an inflammatory barrier to the spreading of the process This barrier however often gives way before the infection which then involves contiguous structures and superficial tissues depending upon the amount of normal resistance of such tissues and the early therapeutic intervention. If localization of the infection occurs, the sheath infection diminishes

both distally and proximally to the involved area Function improves slightly although there may still be purulent exudate present in a localized area of the sheath. The abscess at this time should be drained and all necrotic tissue removed.

The advent of antibiotics has greatly diminished the incidence of severe tenosynovitis and the need for surgical intervention and drainage Much is dependent, however upon the phase in which the surgeon first sees the infection This is often early since severe pain brings the patient to him within the first few hours The effectiveness of repeated *adequate parenteral injections* of penicillin has been well established

In instances of long delay in healing, such as might occur in elderly individuals or when circulation is impaired surgical drainage may be necessary All purulent exudate and necrotic sloughs should be removed, as adequate drainage and removal of necrotic tissue enhances the effectiveness of the antibiotics If fluctuation is present, a lateral longitudinal incision should be made over the fluctuant area and the incision carried through the tendon sheath To drain the cul-de-sac, a transverse incision in the palm may be necessary Incisions in this area must be made with meticulous care in order to avoid the various nerve structures

If the infection has traveled down the tendon sheaths and involved the palmar space or the contiguous areas the swelling will be quite marked distal to the transverse carpal ligament. The palmar concavity will be markedly diminished and the skin distended. However the distention will be somewhat limited because of the dense palmar fascia. All involved areas are excruciatingly tender The wrist may become involved and swelling, redness and fixation may be present. If the infection localizes in either the radial or the ulnar bursa it may rupture under the flexor profundus tendons and extend into the wrist and distal tissues of the forearm and the typical hour glass swelling may occur

Therapy Surgery must be accomplished under adequate anesthesia. If localization has occurred incision and drainage will be necessary A longitudinal incision should be made on the lateral aspect of the involved finger from the base of the distal phalanx to the base of the proximal phalanx. If the lateral aspect of the finger is incised, *there is a much better chance of obtaining* a bloodless field for this procedure If the palmar portion is involved a 1 5 cm (3/5 inch) palmar incision should be made to drain this part of the sheath All exudate and necrotic tissue should be removed with care in order to avoid damage to the proximal annular ligament

Antibiotics must be given in sufficient dosages and at regular intervals The patient's condition may warrant small transfusions of whole blood. The incised area should be irrigated with sterile normal saline solution Fifty thousand units of penicillin in 5 cc. of normal saline should be injected into the proximal end of the tendon sheath. A drain of flat soft rubber should then be inserted and removed within twenty-four to forty-eight hours Penicillin is administered both preoperatively and postoperatively either intravenously or intramuscularly Procaine penicillin 300 000 units is preferable every six hours until the infection has subsided After fixation by splinting the part is elevated and placed at absolute rest. The general surgical principles from the standpoint of nutrition and electrolytic balance are

the same as for any major operative procedure

Complications Infections of the tendon sheath of the flexor pollicis longus or the tendon sheath of the flexor digiti quinti may extend to the ulnar bursa, the radial bursa, forearm fascial spaces in the hand, middle palmar space, lumbrical spaces joints the bones or may rupture to the surface

FASCIAL SPACE INFECTIONS

In the broad grouping there are three main palmar spaces Thenar middle palmar and hypothenar Kanavel however divided these into six fascial spaces (1) Middle palmar space (2) thenar space (3) hypothenar space (4) dorsal subcutaneous space, (5) dorsal subaponeurotic space, and (6) major forearm space These spaces may become involved either primarily or secondarily in infectious spread

Actually there are no well defined fascial spaces There is, however an interval separating the intrinsic muscles of the fingers from the palmar aponeurosis which may be anatomically differentiated by dissection and by breaking down the fibers which unite these tissues The only true anatomical space is on the radial side of the palm and it is in direct relationship with the muscles of the web of the thumb This is known as the thenar space or the adductor space which is wedge-shaped, with the apex lying along the shaft of the third metacarpal bone The base at the first metacarpal bone and the medial border is composed of muscles of the thenar eminence Consequently the space is confined to an area overlying the adductor pollicis muscle The medial wall is formed by the oblique septum the fusion of the distal border limits the space medially and distally The lateral wall comprises the three muscles of the thenar eminence where they contact the adductor obliquus and opponens pollicis The opponens and the short flexor muscles of the thumb extend medially toward the carpal attachments so they also comprise a portion of the roof The floor is the volar surface of the adductor pollicis Distally and laterally the adductor space terminates in the fusion of the dorsal and palmar aponeurosis along the outer border of the first interosseous muscle Between the adductor transversus and the first dorsal interosseous muscle there is a fine connective tissue To produce an actual extension of the adductor space, however the trabeculae must be dissected free in order to connect these spaces to the dorsum of the hand and over the web of the thumb

When infections of the fascial spaces exist there is always associated swelling which often is more marked than it is in tenosynovitis The palmar space is

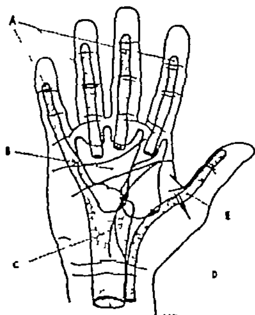


FIG. 4 Synovial sheaths of flexor tendons and thenar spaces. (Modified from Kanavel and Mason in Cyclopedia of Medicine Surgery and Specialties, F A. Davis Company)

particularly susceptible since the infection is frequently superficial to the palmar fascia which causes much distention and loss of concavity of the palm as the infectious process continues The dorsum of the hand may become greatly edematous although the infection is on the volar aspect. After the acute phase has abated the pain is not as marked as it is in tenosynovitis and may diminish as the edema spreads The parts are voluntarily held rigidly flexed and are usually pallid. It is unusual that a hand is allowed to progress to this stage of *infection since such complications can* be circumvented by proper therapy In the event that palmar space infection is widely manifest, immediate administration of antibiotics parenterally is necessary The area of localization and fluctuation should be found and drained through a correctly placed incision.

Middle Palmar Space: The roof of the middle palmar space is the central part of the palmar aponeurosis It extends from the lateral border of the hypothenar eminence to the radial longitudinal crease of the palm The medial wall is comprised of the most medial of the aponeurotic septa The lateral wall is formed by the oblique septum making an obtuse angle with the plane of the floor *The floor is formed by the volar* interosseous fascia covering the interosseous muscles of the third and fourth intermetacarpal spaces and the fourth metacarpal bone Within the space are superficial and deep flexor tendons of the third to the fifth digits, the second, third and fourth lumbrical muscles, and the superficial vessels and nerves for the

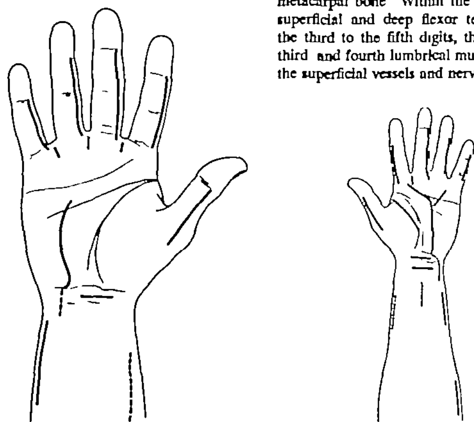


FIG. 5 and 5A. Incisions used for draining infected tendon sheaths and palmar spaces. Dotted lines indicate rarely used incisions—only if essential for adequate drainage after infectious spread into the forearm. Short radial incisions on volar aspect are used to drain web space infections

second, third and fourth interdigital clefts Proximally the roof and the floor are contiguous, so there is no actual communication between the middle palmar space and the forearm The deep forearm potential space is known as the space of Parona. Adipose and connective tissue fill the interstices between the fascial and ligamentous structures and actually obliterate the gaps between the floor and the carpal tunnel and its contents

Infection of the middle palmar space however may extend directly into the deep forearm space of Parona by spreading along the serous sheaths. Distally septa divide the middle palmar space into several smaller spaces The second, third, and fourth lumbrical muscles pass between tendons, and each lumbrical muscle is bounded laterally and medially by a septum These extensions of the middle palmar space make up the lumbrical canal

Note: In several well documented series of patients with all types of open wounds and infectious processes of the fingers and hand, parenteral penicillin or one of the broad spectrum antibiotics has definitely been proven as the treatment of choice Their use has reduced the mean healing time from several weeks to a few days and the rate of complications has been reduced to an absolute minimum Comparable improvement is not attained with the local application of sulfonamides penicillin or other antibiotics nor with local applications of antiseptics In the majority of hand infections, a single daily dose of 300 000 units of penicillin is not sufficient to stop bacterial invasion nor will it prevent complications and multiples of this dose are frequently necessary

Small incisions, when necessary are advocated. This will be described as an atraumatic technic In the event the infection has progressed extensively and the part has swollen more than ten per cent beyond its normal size, surgical intervention is usually required even though antibiotics have been administered parenterally If the part is swollen to twenty per cent beyond its normal size, delay in operation after localization may prove harmful to the patient. The amount of swelling is judged by comparison with the normal structures on the opposite hand, although the hand of dominant use either the right or

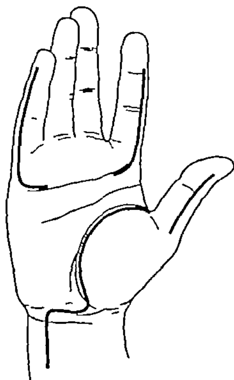


FIG. 6 Types of incisions to expose the volar tendon sheaths. The incision along the medial border of the thenar eminence is carried, when necessary over the medial aspect of the thumb and never over the mid or volar surface The preferred incision is along the lateral aspect of the thumb

The dot illustrates the area of the motor branch of the median nerve to the thenar muscles, this motor nerve must be identified and protected. (Modified from Mason Surg., Gynec. and Obstet., 1934)



FIG. 7 Roentgenogram of joints affected with septic arthritis. Note the fusiform swelling in the phalangeal joints.



FIG. 8 The fist cannot be tightly closed due to arthritic changes in the joints.



FIG. 9 Septic arthritis illustrating the dorsal fusiform joint swelling.

the left, is often slightly larger than the subdominant used hand

Septic Arthritis

Arthritis, following hand infection *rarely gives any difficulty from the* standpoint of diagnosis. Spread into the joint is usually manifested by dorsal fusiform swelling Motion of the inter *phalangeal joints is painful and limited,* and abnormal mobility may be noted if the surfaces of the joint are gently moved from one side to the other Frequently there is a palpable fine crepitation present. Roentgen study will usually confirm the diagnosis If the cartilage has not been too greatly damaged, prompt treatment may result in a useful joint with only partial loss of movement.

Therapy Therapy should consist of incision and drainage of the original lesion, with splinting of the part in a good functional position A broad spectrum antibiotic should be administered parenterally as long as signs of infection persist. In this instance penicillin bacitracin or streptomycin instillations may be of value because of limitations of diffusion into joint spaces of parenterally administered drugs

Human Bites

Human bites are of more than ordinary seriousness They may culminate in mixed infection with aerobic saprophytes and pyrogenic organisms growing in symbiosis, and *highly infected* or gangrenous lesions may result. There is also the possibility of a complication of a heavily traumatized area immediately adjacent to the wound. The infection may easily be spread particularly to the dorsum of the hand, by retraction of the subcutaneous tissues with the variations of flexion and extension of the fingers

If the wound has been incurred with the hand in tight flexion, the infection is driven deep subcutaneously With subsequent extension of the fingers the infection is carried distally thereby providing an ideal location for the anaerobic bacteria to multiply within the tissue planes. Almost any complication may occur from this type of injury including cellulitis abscess formation tenosynovitis, pulp or space infections, and septic arthritis

Therapy The affected part should be thoroughly cleansed and scrubbed for at least ten minutes with soap and water containing hexachlorophene. Grease may be eliminated by washing with ether or benzene If the dorsum of the hand is involved the hand should be held in the position in which the trauma first occurred and the cleansing carried to the depth of the wound. Physiological saline solution may be used to irrigate completely the wound site If devitalized tissue is present, a debridement is performed sparingly

Inasmuch as these wounds are usually contaminated with several types of organisms, penicillin or terramycin combined with streptomycin should be used in both the prevention and the treatment of the infection These agents should be used as soon as possible after injury and continued for a short time after healing has taken place If infection occurs, incision and drainage should be performed as soon as localization is apparent Daily irrigations of warm saline solution are often indicated and in wounds containing thick pus and necrotic material, enzymatic debridement is frequently beneficial

In an injury of this type the hand is splinted with the wrist at 30 dorsiflexion and the fingers semiflexed in the position of function whether or not surgery has been performed. This type of wound should never be closed, even though it appears to be a simple clean laceration

Complications. Suppurative arthritis osteomylitis cellulitis abscess formation and tenosynovitis may all be demonstrated by the signs described under their respective headings The infection may extend beneath the tendons and course toward the volar surface and into the palm Tissue devitalization and reduced oxygen tension produce a perfect medium for anaerobic organisms and, since the tendons have a remarkably poor blood supply their resistance against infection is practically nil Infection may first spread subcutaneously then to the subfascial planes, the subaponeurotic space, the metacarpophalangeal joints the palmar spaces, and the tendon sheaths

Pulp space infections may result in serious complications Gangrene of the superficial tissues may occur and the entire hand should be examined daily for evidence of increased tenderness or space infection. Surgical intervention is resorted to as indicated.

Clostridial Myositis (Gas Gangrene)

Clostridial myositis is one of the most devastating of infections both to the affected part and to the life of the individual. This condition may occur in any wound which contains conditions favoring the growth of anaerobic bacteria

Etiology Clostridial myositis is usually found in deep lacerating, punctured or penetrating wounds in which there is tissue devitalization and compromised blood supply In war these conditions are found in wounds caused by fragments of explosive missiles such as heavy aerial bombs high explosive

shells, trench mortar projectiles, land mines or by distorted bullets from small arms These wounds are almost invariably contaminated by bits of dirty clothing and by soil manure or even human excreta blown or driven into the wound at the time of injury or by secondary contamination The bacteria involved are *Clostridium perfringens* (syn *C welchii*) *Clostridium novyi* (syn *C oedematiens*) *Clostridium septicum* (syn *Vibrion septique*) or *Clostridium bifermentans* (syn *C sordellii*) All are anaerobic spore bearing organisms producing toxins which have hemolytic proteolytic, and necrotizing actions The infection progresses rapidly and is marked by infiltration a typical foul odor edema and considerable vascular engorgement The muscles become dark red and later have a purple cast which progresses to a greenish black The infection may spread throughout the septa and tissue spaces of the hand

Signs and Symptoms: The state of severity varies from a localized inflammatory reaction to severe constitutional disturbance marked by increased temperature often accompanied by chills headache nausea vomiting, malaise and prostration The pulse rate increases with the severity of infection and the blood pressure often becomes elevated. The temperature may show a considerable rise A low temperature with increased pulse rate, however is a bad prognostic sign There is usually an accompanying mental depression and apprehension Pain is severe, steady and throbbing in the early phases and gradually diminishes as the disease progresses to generalized toxemia. Pain may be absent as death nears and the part may become edematous, swollen and increasingly dark in color The skin, first, may be pallid changing gradually to yellow before becoming cyanotic. Upon palpation, the tissues may be indurated, boggy and definite crepitation may be present throughout the subcutaneous tissues where the invasion has occurred If gangrene is due to *Clostridium oedematiens* or *Clostridium septique* there may be no evidence of gas formation and crepitation this however is unusual. The patient may first appear to be flushed and drowsy later advancing to a stage of irritability and extreme apprehension The tongue may be dry and coated and nausea and vomiting may occur The fingers are cold and edematous although the wound area is hot. A foul-smelling thin dirty discharge with bubbles of escaping gas may be noted X ray evidence of gas in the wound is not conclusive evidence of gas gangrene Gas may be present in the tissues about a wound secondary to the entry of a foreign body Culture of the wound may confirm the diagnosis however therapy should be instituted immediately

Prophylaxis The best prophylactic therapy for clostridial myositis is the prompt and thorough treatment of every open wound. It is believed that clostridial myositis does not develop until twenty four to forty-eight hours after injury Consequently if every wound were to be thoroughly cleansed with soap and water as previously described a meticulous debridement performed to remove all devitalized and necrotic tissue and the wound thoroughly flushed the development of clostridial myositis might be prevented. The formation of clostridial myositis is one great factor in the dogma to leave war wounds in which muscle must be debrided and excised open for secondary closure at a later date Immobilization and the early use of antibiotics add much to the arma-

mentarium of prophylaxis for this dreaded condition. This group of clostridia, which are the pathogens in this particular disease are highly susceptible to the action of penicillin Prompt and adequate blood replacement must be made during resuscitation as well as at the time of surgery Specific polyvalent toxoids have been proven to be of value in animals to date however sufficient experimentation has not revealed their efficacy in man

Therapy Clostridial myositis is an immediate surgical emergency All energy should be directed toward this emergency as the condition becomes more serious by the minute. Although prophylactic measures have been followed, there are occasional cases in which infection still develops, usually as a result of inadequate initial surgery of the wound. When this occurs the only hope or cure lies in the early clinical diagnosis and immediate treatment. There must be a complete and thorough cleansing and debridement consisting of wide excisions of all involved tissues, thus freeing the entire area of blood clots foreign bodies and all tissue contamination and devitalization The wound must be opened widely and extensively under adequate anesthesia, preferably pentothal and nitrous-oxide oxygen to permit thorough drainage and aeration to every portion of the wound. If a single muscle group is involved, it can be excised and the hand preserved

If the blood supply to the entire limb has been compromised and several muscle groups are affected then immediate amputation is necessary The amputation of choice in this instance is the guillotine technic and the wound is left open If a single muscle group is involved and it may be excised, the wound is always left open There may be localized anaerobic cellulitis which must be differentiated from clostridial myositis The treatment is surgical in either instance. All necrotic and infected tissues are excised and adequate drainage is established.

Gas gangrene antitoxin has not been found to be of real value Penicillin, in the aqueous preparation, is given 500 - 000 units intramuscularly every three hours It may also be administered in doses of 1 Gm. every twelve hours in 500 cc. to 1000 cc of distilled water with five per cent dextrose solution A total daily dosage of penicillin may be given in amounts of 1 000 000 to 2 000 000 units to control local infection. If penicillin is contraindicated, aureomycin or terramycin may be used in daily intravenous dosage of 2 Gm. This same therapy is used also in anaerobic cellulitis This treatment is begun immediately upon seeing the patient, and it is continued through the operation and postoperatively until all evidence of active infection has disappeared It is essential to maintain the proper physiological fluid and electrolyte balance and to give the patient general supportive therapy Whole blood is used in liberal amounts, as much of the patient's blood is lost by hemolysis as well as at the time of surgery A general high state of nutrition must be maintained If the infection progresses in spite of all these measures, high amputation is the only alternative for saving the individual's life

Progressive Bacterial Synergistic Gangrene

Progressive bacterial synergistic gangrene is a condition in which the tissues are simultaneously infiltrated by microaerophilic, nonhemolytic streptococcus

and hemolytic *Staphylococcus aureus* The lesion is gangrenous and the synergistic action of the bacterial invasion causes an extremely serious condition and may be fatal This condition is unusual in the hand however it may be found seven to fourteen days postoperatively and is usually present in those patients who have had concomitant wounds of the thorax or the abdomen.

Diagnosis The commonest clinical characteristic is excruciating tenderness of the indurated edges of the lesion. The temperature elevation depends upon the size of the lesion, and the polymorphonuclear leukocytosis is commensurate Meleney[8] has well described this lesion, and states that confirmatory bacteriologic studies may fail to confirm the diagnosis because extremely careful anaerobic cultural methods are necessary to identify the tiny colonies of microaerophilic nonhemolytic streptococci

Therapy Bacitracin is the drug of choice and is given in the dosage of 400 units per kilogram of body weight This dosage is repeated every six hours The blood urea nitrogen or the nonprotein nitrogen, is observed every third day *The urine is tested for albumin or casts*, and if this condition is found, the drug is given in the dosage of 300 units per kilogram of body weight every eight hours

Chronic Undermining Ulcer

Chronic undermining ulcer was first described by Meleney in 1935 This condition may occur following a wound or incision and is a subcutaneous infection which spreads slowly

Diagnosis: When the lesion is first observed there may be a very small amount of local reaction but as it spreads slough develops and multiple rounded undermining ulcers are seen. The lesion gives a characteristic appearance The affected area is swollen and indurated. There is a zone of gangrenous skin which has a typical yellowish or brownish-green mottled discoloration resembling suede leather The outer margin is raised and purple while the inner margin is sharply defined and crenated and of a darker purple than the outer portion of the circle. This condition may be present for months or years Some lesions heal spontaneously while others continue to progress unless treated. The amount of pain varies however it may be excruciating There may be general systemic reactions such as temperature elevation and general malaise The infecting bacterium is the microaerophilic hemolytic streptococcus which responds to bacitracin in the dosage of 200 000 units intramuscularly four times daily This is given in combination with penicillin in daily dosages of 600 000 units, It may be found necessary to cauterize the entire area. After the lesion has been cured, appropriate skin grafts may be applied as indicated

Wound Diphtheria

Diphtheritic infection of an open wound of the hand is rare however it may progress systemically and lead to fatality

Diagnosis Locally there is a typical diphtheritic membrane with a purulosanguineous adherent fibrin on the surface of the wound The diagnosis must be confirmed by laboratory measures. If the disease progresses systemic signs are noted of facial paralysis and a syndrome similar to that of the Guillaine Barré syndrome

Therapy Diphtheria antitoxin is given immediately and in combination with penicillin or one of the broad spectrum antibiotics

Tetanus

Tetanus is an acute infection caused by a *diffusable exotoxin produced by Clostridium tetani* This exotoxin acts upon the nerve tissues, and may be lethal depending upon the amount of toxin which is fixed by the nervous system Tetanus may be a complication of any wound of the hand. All patients having penetrating wounds of the hand, or burns from any source regardless of how trivial the wound appears should be given tetanus antitoxin routinely The incubation period of tetanus is usually four days to three weeks dependent upon the character and extent of the wound. Longer periods of incubation have been noted Operative interference or local tissue changes may initiate the activity of quiescent bacilli at even longer periods after the original wound infection.

Diagnosis This condition is characterized by painful muscular contractions primarily of the masseter and neck muscles, and secondarily of those of the trunk a history and usually physical evidence of a wound of entry for infection are found Superficial suppuration under a gauze dressing or a crust provides sufficient anaerobiosis for the tetanus bacillus to develop The jaws may later become stiff and rigid convulsions may be noted in the terminal stages See Chapter 46

Therapy Prophylactic Methods Active immunization with tetanus toxoid is desirable for those likely to be exposed to infection with tetanus Active immunity can be accomplished for a period of four years by two subcutaneous injections of tetanus toxoid (1 cc each) at six weeks intervals followed by a third injection in the same amount, six months later If a patient who has been previously immunized sustains a wound in which tetanus may develop he should be given 3000 international units of tetanus antitoxin when first seen This injection should be repeated weekly if the risk of infection seems likely A booster injection may be given in the dosage of 1 cc. of toxoid

It is necessary to remove all foreign matter as early as possible from all wounds The debridement must be complete with removal of all necrotic and devitalized tissues, and if the blood supply of the tissues is adequate all parts of the wound may then be considered adequately oxygenated, and if the tetanus spores are then present, conditions are not suitable for germination Although a wound may heal this fact is no protection against tetanus Wound healing superficially may be extremely dangerous Tetanus may develop even in immunized patients Consequently complete surgical treatment of all wounds is the basis for prevention of tetanus

Specific Therapy See Chapter 46

Erysipelas

Erysipelas is a contagious acute febrile infection of the skin and subcutaneous tissues caused by beta hemolytic streptococci It is most frequently found among older persons and those suffering from debilitating diseases

Signs and Symptoms The prodromal symptoms are malaise possible nausea and vomiting, headache and chills and fever The temperature may rise to 103 F or 104° F (39.5° or 40 C.) with a concomitant rapid pulse rate of 120 or over The leukocyte count may be increased to 30,000 or more with the polymorphonuclear range to ninety five per cent. The lesion may appear suddenly as a localized erythematous patch with a well demarked, raised, and indurated margin at a cir

completely penicillin resistant although normally penicillin is effective In the advent of complete penicillin refractivity one of the broad spectrum antibiotics may be employed. Aureomycin terramycin erythromycin, or carbomycin in daily doses of 20 to 30 mg per kilogram of body weight may be used *There are also* intravenous preparations of the majority of antibiotics which may give more rapid action with higher concentrations In severe infections the antibiotic must be administered for five to ten days after the local signs of infection have disappeared and the temperature has returned to normal Two or more antimicrobial drugs each having different bacteriacidal powers may be administered either in combination or in alternative courses however this is employed under strict surveillance and control

The administration of aureomycin or terramycin may cause gastrointestinal disturbances and perianal irritation This is due to the destruction of the organisms involved in the synthesis of vitamin B_{12} Patients suffering with this reaction are relieved by the oral administration of two teaspoonfuls of elixir of vitamin B_{12} folic acid, and ferric ammonium citrate four times daily

Antibiotic therapy is not effective in eliminating abscesses or areas of specific localization of exudate Drainage is the only means whereby these lesions may be resolved. After incision and evacuation of its contents the cavity may be flushed with a solution of penicillin or bacitracin (5000 units ... per cc) If streptomycin ... iotic of choice 10 mg. per cc ... y be instilled If instill... g drainage or aspiration only to complement the teral injection of the

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Antitetanic serum is given immediately upon arrival of the patient at the hospital. It is difficult to fix dogmatically or state a specific time limit concerning the potential sepsis or asepsis of a given wound in the event of thorough cleansing, antibiotic therapy and the application of sterile dressings with aseptic technic Salient factors in regard to sepsis and potential sepsis are knowledge of the offending object, whether or not it is considered one of gross contamination such as injury resulting from a dirty horseshoe *foreign body contaminants* from the soil or battle casualties from land mines in fields of infected material. Wounds in civil life are usually from relatively clean machinery or objects carrying grease, dirt, or oil into the wound but not heavy contamination Fortunately the great majority of civilian industrial wounds are seen within a few ... definitive surgery and primari... may be accomplished.

...IC LESIONS ... HAND

HEMA...

trauma

tively minor injury may cause excruciating pain, since the hematoma is under great pressure An examination usually reveals a dark blue discoloration beneath the nail in the area of traumatization with considerable swelling and distention of the eponychium.

Therapy Relief by surgical intervention before the blood has clotted is the treatment of choice One method is the placement of a scalpel between the eponychium and the nail and gently teasing this area until the blood escapes If the hematoma is completely subungual, a small opening may be made over the discolored area to permit the escape of blood A transverse incision should then be made through the nail A tiny dental drill may be used for this purpose but care should be exercised so as not to add to the pressure which in turn will increase the pain When the opening has been made, a small amount of pressure should be exerted to remove the blood and serum The nail itself will protect the injured area, but a small dressing should be placed over the incision

Traumatic Wounds, General Considerations

Koch[8] has postulated an excellent summary of principles which are the basis for optimal treatment of traumatic wounds of the hand

1 The open wound must be protected from infection

2 Bleeding is arrested.

3 The extent of the injury is then determined

4 The contaminated wound is transformed into a clean wound

5 If a clean wound can be accomplished the fractured bone fragments are aligned the injured structures are repaired, and the wound is closed.

6 If the asepsis of the wound is questionable fractures are reduced, but injured tendons and nerves are not repaired The wound is left open if the wound edges cannot be approximated without tension.

7 The entire injured area is covered with a large compression dressing

8 A splint is applied to keep the hand at rest.

When the wound is first incurred, hemorrhage must be controlled by elevation and gentle pressure over several layers of sterile dressings, or if this measure is unsuccessful a compression cuff should be used until more adequate methods can be undertaken under aseptic conditions. A blood pressure cuff placed on the arm or forearm and inflated above the systemic pressure usually affords sufficient constriction to control bleeding and obviate undue compression and injury to the nerves If a patient is admitted to the hospital with a tourniquet in place, he must be given top surgical priority

Parenteral penicillin or a broad-spectrum antibiotic and antitetanus serum should be administered when the patient is first seen as a prophylactic measure This measure is the same as for treatment of established infections (*q v*)

Wound Evaluation Diagnosis of extent of the injury should always be made insofar as possible before specific surgical intervention is undertaken Motor and sensory nerve changes should be carefully noted. Sensory changes may be detected by testing with the point of a needle over the area of the hands and fingers corresponding to the distribution of the various nerves to determine areas of anesthesia or paresthesia. The ability of the patient to hold the hand and fingers rigid without abduction adduction or extension must be tested The joints

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TRAUMATIC LESIONS OF THE HAND

Subungual Hematoma

Subungual hematoma following trauma to the fingernail, though a rela-

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should be carefully examined and muscle strength determined by resistance evaluation Possible fracture by gross signs and by roentgenographic study in several planes should be studied Vascular injuries are evidenced by hemorrhage pallor cyanosis of the part, absence of pulsation and lowered skin temperature. Wound cleansing and repair must be performed in a systematic manner beginning at the site and progressing distalward After thorough cleansing the blood pressure cuff should be released so that the suspected nonviable tissues might be properly evaluated and the presence or disappearance of ischemia observed.

Devitalized tissue does not bleed. The skin and subcutaneous tissues will be white or gray and the muscles purple and unreactive to stimulation The evaluation of fascia, tendon sheaths tendons and nerves must be done with the greatest of care as they may be stained with blood or foreign material such as gunpowder Completely detached bony fragments may be removed and bone fragments with periosteal or muscle attachments replaced and left in *situ* It should always be borne in mind that there is no excess tissue in the hand or fingers and there is no medication which will cause expulsion of contaminants and foreign substances

Utmost patience care and time must be given to the cleansing of a wound, especially when the tissues are mangled and torn The surrounding tissues may be cleansed with carbontetrachloride ether or benzene to remove grease The wound is thoroughly cleansed by gentle irrigation with sterile water Every recess must be exposed by gentle retraction. Surgical gloves must be changed after cleansing and before proceeding to definitive care Foreign bodies must be



FIG. 11 Traumatic wound of hand. Hand injury following trauma from enemy grenade which exploded as it was caught. This will be a well functioning hand

carefully removed by gentle dissection so that no further damage to the vascular channels, nerves, or tendons will result. If any doubt exists as to the depth of the foreign body the area surrounding it should be incised and dissected before attempting removal A pair of binocular loupe spectacles greatly facilitates meticulous removal of tiny bits of foreign material In such a procedure requiring very delicate instruments nerve hooks and vein retractors will be found useful.

Careful consideration should be given the time which has elapsed between the initial injury and the patient's arrival at surgery This time element may be a factor in determining whether the wound should be considered contaminated and allowed to heal without specific repair and closure, or whether it should be closed primarily and the healing time extended over a period of weeks The closing of the wound depends upon the amount of time which has elapsed the circumstances under which the wound was incurred, and the nature of the contaminants A wound which is more than twelve hours old when it is first seen or a wound in which purulent ex

udate is noted is left open. Wounds may be heavily contaminated with both aerobic and anaerobic bacteria

Extensive skin loss should be corrected as soon as it is practicable in order that the graft may be placed on a base the physiology of which is as nearly normal as possible Delay in clean wounds invites infection granulation fibrosis and scarring with decreased possibility of primary growth and healing Although the wound may gape widely and have jagged and irregular edges there may be little actual loss of skin An injury of this type may be sutured at once or at the time of secondary closure Primary suture is done whenever possible since open wounds encourage complications If the edges cannot be approximated and the wound closed adequately without undue tension the raw surfaces if over 2 cm (4 inch) in diameter should be covered by a graft This may be a split thickness graft if skin only has been lost. If there has been extensive loss of underlying tissue however full thickness pedicle or sliding grafts may be required

A distinction must be made between battle casualties where definitive treatment has been delayed twelve hours or longer and wounds suffered in civil life which come to surgery immediately after injury Industrial wounds or other wounds occurring in civil life may be repaired and treated in a well-equipped hospital usually at the time of initial observation Following definitive surgery the hand may be placed on the Mason Allen[14] hand splint or similar type splint for proper position and support

Skin Grafting The best functioning hand following injury are those in which early healing and motion are obtained The more prolonged the healing and inactivity of the part, the more difficult will its restoration to normal function be

Fingers As a rule if there is a simple avulsion of skin from the finger with no exposure of bone joint or tendon and if the area cannot be approximated and closed, a suitable split thickness graft may be taken from an appropriate portion of the body and shaped to correspond to the area of skin loss A free split thickness graft is generally the most useful in repairing defects in which the skin and subcutaneous tissue have been avulsed The split thickness skin graft, otherwise known as a "Thiersch" graft, is approximately 0.2 mm (0 008 inch) thick and has little place in repair of hand injuries except as a temporary skin dressing The intermediate or "Blair" graft of 0.25 to 0 4 mm (0 01 to 0 016 inch) is more appropriate for routine use to give satisfactory thickness If the pad of the volar surface of the finger has been avulsed a split graft from 0 4 to 0 65 mm (0 018 to 0 026 inch) thick should then be placed

Absolute asepsis is essential in order to insure success in the *transplanting* of the skin Complete hemostasis is imperative since bleeding separates the graft from its bed and resulting blood clots act as foreign bodies and nullify "take" Fibrosis will occur following hemorrhage and will further decrease the flow of nutrient materials from bed to graft In preference to using suture ligations bleeding points may be clamped with tiny hemostats and held for a few minutes Tissues must be handled very gently and traumatization by large hemostats or heavy traction forceps must be prevented No caustic or alcoholic antiseptics should be used on the graft or the recipient area either preoperatively or postoperatively A few bast

ing sutures of nylon or very fine stainless steel should be placed at the edges of the graft to anchor it in place

Full-thickness grafts are particularly suitable in areas where trauma in day to day use normally occurs When using full-thickness grafts the pattern should follow the exact size and contour of the recipient area. The underlying fat should be removed since it only tends to necrose and compromise the final result. The graft is applied and sutured without tension to the recipient area Even compression must be maintained over all grafts by the application of a proper dressing To obtain a uniform pressure dressing a dry sterile fine mesh gauze (roller bandage) should be placed immediately over the site of graft and the area padded with sterile gauze mechanic's waste or sea sponge, and bandaged to maintain even pressure and immobilization Thin grafts may be examined after seven days The full-thickness graft, however should not be examined until ten to twelve days have elapsed because "take" is slower unless pain, odor or exudation are present, and warrant inspection of the wound On first inspection the sutures should be removed and compression dressings reapplied and left in place for four days before re-dressing Gentle pressure should be maintained over the graft area for three or four weeks postoperatively The donor area may be treated simply by applying sterile fine mesh gauze if only a thin or split-thickness graft has been removed. If a full-thickness graft has been taken the donor site should be partially closed by suture and a split thickness graft taken from another site and placed over the residual defect Redressing of the donor site is done in fourteen days, when healing has been attained.

Avulsion of Finger Tip

In the event of traumatic amputation of the finger tip, the stump defect should be carefully and adequately covered, and as much of the bone preserved as possible The stump must be covered with full thickness skin which is durable enough to withstand continuous and rough use Volar surface scarring should be held to an absolute minimum The wound should never be left open to granulate and heal by scar tissue, as the scar always results in a painful area which may break down with the slightest trauma Simple closure of the wound, if the bone has been exposed, means loss of bone length since the bone must be shortened in order to accomplish closure. The resulting sensitive linear scar will also produce a painful finger tip Split-thickness grafts are not successful, since this skin cannot withstand the rigors of finger usage



Fig. 12. Pedicle flap method of obtaining a serviceable finger tip. The X marks the line of incision.

Therapy The entire hand should be thoroughly washed for ten minutes with hexachlorophene solution in soap or emulsion, and a site for pedicle graft chosen from the palmar surface of the same hand The injured finger should

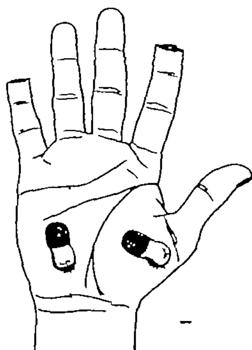
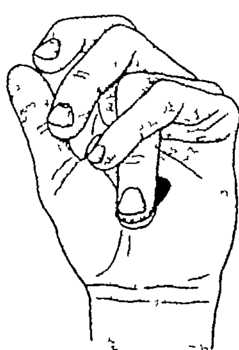
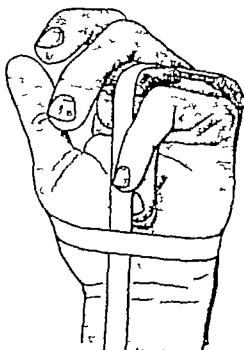


FIG. 13A Illustration showing technic of pedicle flap to avulsed finger tip. Lateral and proximal types of pedicle flaps. (Jones, Robert A., Am. Jour Surg. 55 331 1927)



B



C.

FIG. 13B Method of suturing flaps to defect on finger tips. Avoid the kinking of flaps. (From Ferguson, L. Kraeer Surg of the Amb Patient, page 574 J B Lippincott Co., Phila., Pa.)

FIG. 13C. Completed operation, first stage. The palm wound has been sutured after uniting flap to the finger tip (Ferguson, L. Kraeer Surgery of Amb Patient.)

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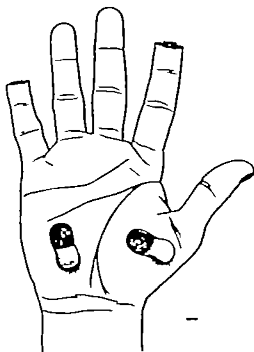
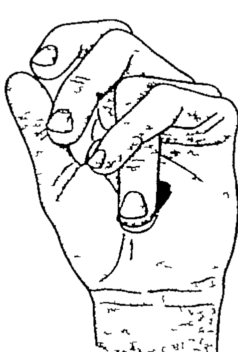
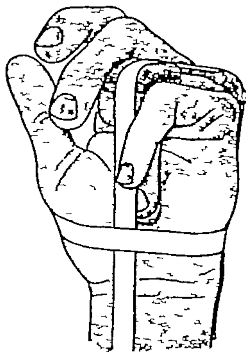


FIG. 13A. Illustration showing technic of pedicle flap to avulsed finger tip Lateral and proximal types of pedicle flaps. (Jones, Robert A., Am. Jour Surg. 55 331 1927)



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FIG. 13C Completed operation, first stage The palm wound has been sutured after uniting flap to the finger tip. (Ferguson, L. Kraeer Surgery of Amb Patient.)

be flexed to a comfortable position on the palm from which a U-shaped pedicle flap is to be taken If the thenar eminence is chosen a transverse horseshoe pedicle flap of full thickness may be partially detached from it It may be more comfortable for the patient however if a lower portion on the palm of the hand is chosen Wherever the pedicle site is chosen a U-shaped portion is dissected Care should be observed in allowing for adequate width and length and an incision made in the pedicle to insure the attachment of the subcutaneous fat to the grafted portion. The pedicle should be formed so that the open portion of the "U" is directed toward the wrist This is a relatively simple procedure if all sutures are inserted both in the flap and at the wound edges of the finger before being tied. The defect of the donor site may then be undermined and closed with interrupted sutures or a small split thickness graft from another portion of the body may be used After suturing with nylon or stainless steel wire the suture lines should be covered with vaseline gauze The entire hand and fingers should be padded dressed, and a cast applied to give stabilization and to prohibit undue tension being exerted on the pedicle

In ten to twelve days the cast may be removed, the wound dressed, the sutures removed the uninvolved fingers exercised, and the finger which has been operated upon re-dressed and resplinted. The pedicle may be detached after the third week The graft should be remolded and sutured into place on the finger and the defect in the palm closed After seven days these sutures may be removed The patient may gradually resume his normal activities within three weeks following removal of the sutures. This type of graft is very satisfactory and allows a workable surface after healing

Mutilation of the Thumb

The thumb is the most important digit of the hand, since it acts as a pincer and stabilizer when grasping In the event of partial amputation of this member it is well to conserve the remaining bone if possible, regardless of whether or not the soft tissues around it have been avulsed After thorough cleansing has been accomplished a suitable site on the abdominal wall or upper thigh may be chosen and a pedicle graft of full-thickness formed to meet requirements The flap is rolled around the denuded surface and fixed to the digit, using nylon or fine stainless steel wire for sutures The donor site may be approximated and partially closed and the pedicle severed in fourteen days to three weeks Molding and suture of the thumb is then accomplished to form a well-functioning part.



Fig. 14 Traumatic amputation of the thumb and first two fingers.

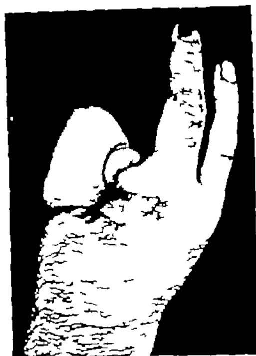


FIG. 14A. Same hand shown in Figure 14 following first stage revision with useful stump as a thumb



FIG. 15 Thumb replaced by adjacent index finger graft



FIG 15A Grafted finger serves as a useful thumb the second toe has also been successfully grafted to the thumb site in some cases.



FIG 16 Mutilated thumb With careful surgery prevention of infection, and time for healing, many torn members are saved.

TOTAL AVULSION OF THE SKIN OF THE HAND

The type of graft to be used depends upon the depth of overlying tissue avulsion If the surface skin has been removed, as often occurs in wringer injuries crushing wounds, or burns early replacement of covering tissue is mandatory If bone cartilage, or tendon is not exposed, separate grafts may be used of either split or full thickness to accommodate the amount of tissue loss

As long as its blood supply has not been compromised, all remaining skin must be used even though it appears dirty or is hanging by a pedicle If however there has been a total avulsion of the superficial tissues, and blood vessels nerves bones, joints or tendons are exposed a full-thickness pedicle graft is required As a rule tunnel or

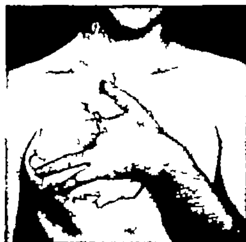


Fig. 17 A type of pocket or glove graft very useful in some injuries.



Fig. 17A. Dorsal view of Figure 17



Fig. 17B Lateral view of Figure 17 A well functioning digit



Fig. 18 Two denuded hands following severe burn awaiting graft.

pedicle grafts are more successful if obtained from the upper thigh unless the abdomen is thin or the patient is a child.

If the hand has been totally degloved the procedure of choice after thorough cleansing and asepsis is to implant the hand into a subcutaneous pocket of the abdominal wall or the upper thigh. The implantation should be through a tunnel graft with the graft sutured to the skin of the wrist, fingers or hand wherever possible This type of graft is left in place from fourteen to twenty-one days at which time the lateral portion of the graft is separated from the abdominal skin molded and resutured to the hand. The medial portion of the graft should be separated seven days later The tissues on the hand may then be remolded and sutured the donor site should be partially closed by suture and split thickness graft

Temporary Graft If the underlying structures of the hand have been heavily mutilated, severing nerves tendons, and compounding fractures, it is essential to reduce the fractures and cover the denuded areas with a full-thickness graft. This graft should be taken from the abdomen and should maintain a satisfactory cover for these vital structures Definitive therapy on nerves and tendons may be accomplished after complete healing of the wound

Irradiation Injuries

Excessive amounts of irradiation may cause deep burns and complete devital

lization of the skin and underlying structures. Nail malformation or atrophy areas of telangiectasis, pigmentation, keratosis, desquamation scarring, or ulceration of the skin may be seen Ulcerations from this type of injury are dangerous from the standpoint of potential carcinogenesis These injuries should be treated as burns Their vascularity is reduced because of fibrosis The areas of injury must be removed to the limiting line of normal epithelium An appropriate graft should be placed commensurate with the location and depth of injury Poor healing will result if all the devitalized skin is not removed.

There is always a possibility of ankylosis of the joints following irradiation The hand should be placed in a position of semiflexion with 30 dorsiflexion of the wrist if possible It must be remembered that thin partial-thickness grafts, although expeditious and efficient, do not allow for sufficient elasticity and are consequently inflexible over joint areas It is well to evaluate carefully the type of graft to be used, whether it be split thickness or pedicle Pedicle grafts withstand trauma and permit tendon and joint movement much more readily than do free or split thickness grafts A full-thickness graft, either free or pedicle is the method of choice, since it will withstand temperature changes and trauma and permits an early return of sensation.

Full-thickness skin grafts, to some slight degree, tend to atrophy However this rarely occurs to the extent of interfering with their fixation With time, sufficient tissue proliferates beneath the graft to cushion against trauma and undue tenderness. There is a great advantage in using stainless steel wire of a small caliber rather than silk or other types of sutures. Since steel has no capillary action, there is little chance for skin infections being drawn into deeper structures There is also little tissue reaction to steel, and therefore it may be left in place longer than any other type of suture material

Damaged and healing tissues require rest and support until they have regenerated strength enough to carry on their functions The hand must always be splinted and supported following operation, as well as after injury to prevent further trauma and to reduce pain. All injured hands tend to assume a position of nonfunction with the wrist flexed, the fingers cocked back, and the thumb drawn in close to the hand or into the palm. If a hand becomes stiff in this position it is virtually useless The hand and fingers must never be splinted in the extended, straight position, as in a banjo splint. They should always be placed in the position of slight flexion with the fingers and thumb slightly abducted, the thumb slightly forward from the hand, and the wrist placed in dorsiflexion about 30 The little finger should be slightly more flexed than the remaining fingers and the metacarpal and carpal arches placed in a position of a circle as in grasping a ball. This is the position of best function.

THERMAL INJURIES OF THE HAND

Burns

Burns of the hand, including powder burns are very common and should be treated in the same manner as burns elsewhere on the body Meticulous care must be taken since the accumulation of granulation tissue, following this type of injury can cause very disabling contractions

charred, or dark yellow in color In this event, sharp excision of the necrotic area is advisable Obviously infected bone or detached sequestra may be re moved, but it is difficult to ascertain how much osteogenesis will occur It is best to cover the entire area with a full-thickness pedicle or pocket graft. By following this mode of therapy the open wound, with its high risk of infec tion is converted into a healthy closed wound with complete epithelial covering The healing time is minimized, and active exercises can be given to the hand as quickly as the grafts are stable thereby maintaining proper function in the joints and tendons. If grafting is de layed, edema and fibrosis are inevitable and prolong the time of healing

Infected Burns. An obviously in fected burn usually requires a daily changing of dressing depending upon the amount of exudation present. Complete cleansing measures are performed with each change of dressing All devitalized tissue is removed, and the hand is gently scrubbed, as previously de scribed When the surface is surgically clean the denuded areas are grafted without further delay

Antibiotic Therapy The value of systemic antibiotics is to prevent invasive infection. Cultures are taken at the time of debridement and cleansing, to deter mine the type of bacteria present Topi cal application of antibiotics is usually ineffective as it is pushed away from the wound by the constant serous exudation. When the patient is first seen, antibiotics should be administered and the daily dosage continued, using 600 - 000 units of procaine penicillin for five days after the initial operation. Aureomycin or terramycin in 2 Gm. daily dosages by mouth may be administered in the event of penicillin sensitivity The infection, if present, is usually caused by hemolytic streptococci and these organisms are usually eliminated by systemic doses of penicillin

After complete debridement and cleansing of third degree burns the en tire surface of the burn is covered with a nonadherent type of sterile dressing preferably fine mesh gauze (roller bandage) The fingers are carefully spread and dressed separately to avoid contact one with the other A gentle pressure dressing of mechanic s waste is applied and kept under continuous and equal compression. The fingers are individ ually dressed Splinting is essential. The hand is placed in the position of func tion, the wrist being at 30 dorsiflexion, and the fingers in the position of slight flexion for best function. If the dressings are later saturated with purulent exudate the second degree burn will lose its healing power and will be con verted into a third degree process if allowed to remain without a change of dressing and wound cleansing

Frostbite

In frostbite the logical factors to be considered are the intensity of the cold, the duration of exposure wind velocity contact with metal, moisture of the clothing, and external constriction of the limbs by clothing or position These factors are dangerous to the flyer espe cially at great altitude Resistance to cold is strikingly lowered if circulation is impaired, either generally or locally Local impairment may be due to previous frostbite, to circulatory disease, smoking, or general debility The wounded anoxic individual, or the anemic type is more susceptible to the deleterious effects of cold. Freezing of the skin as a rule, does not occur until the environmental temperature is −26 F



FIG. 19 An example of frostbite in which demarced area had the appearance of gangrene. The gangrenous parts slipped off leaving normal tissue



FIG. 20 Severe frostbite with definite lines of demarcation.



FIG. 1 Moderately severe frostbite.

(−32 3 C) Perspiration under gloves increases the chances for freezing on exposure to these temperatures Contact with metal surfaces at low temperatures often results in instantaneous freezing as well as fixation of the skin to the metal object and removal of the hand or fingers from the object results in a tearing of the skin

Pathophysiology· The pathophysiological changes occurring in frostbite are (1) ischemia, (2) freezing and crystallization, (3) hyperemia, (4) necrosis, and (5) healing. Frostbite is the result of freezing of the skin and subcutaneous tissues, causing actual crystallization of the intracellular and intercellular fluids which, in turn destroy the cellular structures

Frostbite like other thermal injuries, varies in intensity The first degree manifestations are swelling and redness as vasoconstriction occurs, followed by vasodilatation and progressive swelling Ischemia of the tissues caused by the circulatory embarrassment, then takes place The frozen extremity is hard white and waxy and may be friable to touch. Second degree changes include cyanosis, swelling, and vesicle formation with progression to ulceration Pain usually does not occur before the swelling begins However during and after thawing and the marked accompanying vasoconstriction, pain may persist for hours Hyperemia ensues when the circulation is restored. Edema and vesication then become marked The skin later becomes dark and covered with blebs Hyperemia accompanies vasodilatation and later if the capillary endothelium has been destroyed by freezing, there may be an extravasation of blood into the tissues Various points of thrombotic occlusion may be found in sectioned tissues at the arteriolar-capillary

junctions. These thromboses are found in the dry gangrenous tissues which follow frostbite. The third degree of frostbite is manifest by gangrene of the involved area. If the tissues are not viable the pain is immediately followed by anesthesia; if the tissue is viable, hyperesthesia or paraesthesia will ensue. If there is complete loss of viability a line of demarcation usually develops within a few days. It has been observed that the contraction of the black necrotic eschar frequently results in ischemic necrosis of a digit. To prevent this, the eschar should be bivalved as soon as possible. If the eschar is too thick and dense it may be softened by soaks in warm sterile normal saline containing zephiran. Salves or ointments should not be used as they increase the possibility of infection and ulceration.

The dry gangrene is the end result of the inability of the blood to penetrate the capillary bed, thereby shutting off all nourishment to the part. Necrosis then occurs in the frozen anoxic tissues because of prolonged vasoconstriction, and the gangrenous area becomes desquamated or mummified. This results in spontaneous amputation when the process is completed.

As the frozen finger or hand thaws the pain, swelling and hyperemia are intensified if the tissue is still viable. The pain and swelling are due to the marked extravasation of fluid with ensuing inflammatory reaction in the tissues. Similar manifestations of marked circulatory impairment are found with exposure to below freezing temperatures. Sensation in the regenerated skin is usually impaired and there may be hypersensitivity to thermal changes. The skin then appears shiny red, and dry. Involved bony structures later reveal roentgenographic signs of osteoporosis.

Clinically it is impossible to determine the extent of tissue damage without prolonged observation. The majority of the black eschars exfoliate and leave a pink, healthy and sensitive skin. Nails may exfoliate and are replaced by new nails. Mummified fingers may gradually exfoliate, leaving a normal finger; consequently no one can determine whether amputation will be required until after a period of three months have elapsed.

Therapy. The patient is treated with 50 mg heparin every four hours for forty-eight hours and 40 mg. of hexamethonium twice daily for two weeks. ACTH and cortisone may lessen the pain, decrease the purulent drainage, hasten demarcation of the necrotic area, and result in mild euphoria. These drugs do not, however, decrease the amount of tissue lost or hasten final healing.

Immersion Hand

Immersion hand is a separate entity and must be clearly differentiated from frostbite. In frostbite there is actual freezing of the skin and the deeper tissues, whereas in immersion hand no freezing has occurred. Immersion hand is a term given to this part by sailors who first noticed its onset after immersion in the sea for many hours. This condition has been found, however, in some instances, without the part actually having been immersed in water. It has occurred in some cases after exposure to extremely low temperature and high altitude usually when gloves were soaked with perspiration. The stages of immersion hand may be described as follows: (1) Ischemia, (2) hyperemia, (3) consolidation, (4) healing.

Etiology with Early Symptoms and Signs. Swelling and ischemia may be



Fig. 22. Immersion hand

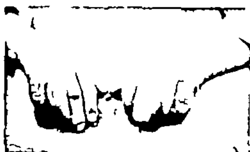


Fig. 23 Immersion hand

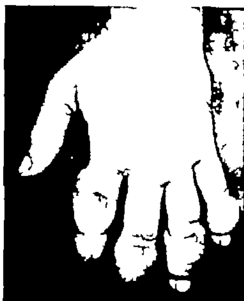


Fig. 24 Immersion hand.

noted after prolonged exposure to immersion temperatures of 78 F (25.5 C) to 55 F (12 8 C) The same phenomena have been noted without immersion at temperatures increasing proportionately as the temperature scale descends

Although the cause usually is due to many hours of immersion in sea water it has also been encountered after a limb has been immobilized at low temperatures and in cold weather when the hand has been in wet gloves for a long time Other factors contributing to its development include the constriction of the circulation by tight fitting gloves or wrist bands, prolonged dependency of a part, and immobilization in cramped positions such as those often required of certain airmen who must stay in a small compartment for many hours at a time

Pathophysiology The condition of immersion hand is secondary to loss of tissue heat, vasoconstriction and circulatory stagnation with trauma, fatigue dehydration and poor nutrition accelerating its onset The stage of ischemia results in capillary anoxia and greatly increased permeability of the capillaries thereby permitting exudation and edema The involved part is completely blanched and sensory changes are experienced A tingling or pricking sensation which may begin immediately or may not start until the end of the first or second week are the usual sensory disturbances With dependency of the part there may be severe cramps, or the entire arm may ache and throb with each pulsation Pain is usually worse at night and is increased by straining temperature increases, or the mere pressure of bed clothes. Although sensory loss may be present, the neurological reflexes are usually normal. There may however be a loss of the proprioceptive sense. The part is cold and may appear cyanotic light blue or bluish-black and in the

later phases is swollen Radial artery pulsation may be weak and thready

The condition of the hand then merges into the stage of hyperemia in which the part becomes hot, red, and definitely more swollen. This usually occurs when the part is exposed to warmth and is marked by vasodilatation with inflammatory hyperemia, resulting in the release of histamine-like substances caused by the general tissue and blood vessel injury There may be occasional sharp deep pains however they usually are not present until after the sixth day Multiple petechiae in the skin and thrombophlebitis of the dorsal veins may be present. Pressure on any portion of the reddened areas causes blanching except where gangrene or blanching already exists When treatment is first begun, the swelling increases and is accompanied by pitting edema over the volar and dorsal aspects of the hand and forearm Petechial hemorrhage and ecchymosis are particularly noted in the web of the hand and over the surface of the digits. The swelling may not subside completely for several weeks The affected part has the feeling of a wooden appendage or prosthesis to the patient. Anesthesia, hyperesthesia, paresthesia, and vasomotor disturbances are the results of peripheral nerve involvement. If the hand is in continuous contact with water moisture, or snow the skin usually remains in the hyperemic stage for fourteen to twenty days The hyperemic stage has been known to last as long as four months. Patients suffering with less severe involvement may have no bleb formation, whereas in the more severe forms blebs containing blood or yellowish colored fluid appear This may not appear until therapy has been initiated.

Following this stage, swelling may diminish and consolidation will be noted by firmness in the subcutaneous tissues There may be some bleb formation and later complete desquamation with the appearance of shallow superficial spots of gangrene or gradual formation of areas of linear demarcation. Areas which develop gangrene are prone to have heavy and deep bleb formation. The entire skin of the involved area is thick, later becoming dense and hard, and the hair and fingernails are lost with complete desquamation of the entire involved surface. When the affected part has been removed from the causative environment, the fingers and hand remain warmer than the unaffected parts of the body Although the entire hand and all the fingers may be discolored, it is quite unusual for the entire hand or even a single digit to be lost. With the exception of the points where gangrene is apparent, pain usually exists in all the areas If gangrene does appear the line of demarcation forms late The fingers and hand will be red with a slight cyanotic appearance and may have spotty patches of early gangrene with a gradual formation of a line of demarcation. The muscles may later show signs of atrophy Anhidrosis coincides with the area of sensory loss however this phenomenon returns during the healing stage more rapidly than do peripheral sensations. Study of the bone may reveal osteoporosis Systemic findings may be slight increase in temperature of 99° to 100 F (37.2 to 37.8 C) which may persist throughout the hyperemic stage mild leukocytosis, transient albuminuria, and tenderness to pressure exerted over the liver In the stage of consolidation and resolution intermittent swelling may occur the sensory changes gradually return to normal, and hypersensitivity on the dorsal and volar surfaces may exist.

fully treated with aqueous merthiolate or a solution of sodium hypochlorite The premature removal of dead or sloughing tissues should be guarded against. If gangrene develops it is usually superficial and will be eliminated naturally with general systemic care The application of tryptar or streptokinase-streptodornase may be helpful in removing postgangrenous areas of slough and necrosis The application of petrolatum oils, or greases is contraindicated. Vesicles and blebs should not be opened. When edema and swelling have disappeared and the part is no longer in the hyperemic stage, general massage passive exercises, and warm whirlpool baths may be employed.

In the Korean war when frostbite casualties were found within four days after injury they were given an intravenous solution containing 250 cc. of five per cent glucose 12 cc of alcohol, and 250 mg of procaine If there were no concomitant battle wounds which might produce hemorrhage, the solution given also contained 100 mg of heparin. This infusion was administered every six hours Hexamethonium was administered early and smoking was forbidden. Immersion hand is a debilitating condition and because of their lowered resistance to thermal changes, patients may be unable to return to their former duties even after rehabilitation

TENDON REPAIR

General Considerations. Skilled assistance and a good anesthetist are of prime importance in the undertaking of tendon repair Ordinarily a tendon in an open wound should not be repaired primarily if twenty four hours have elapsed since the time of injury The wound may appear clean, but edema and dissemination of contamination is usually present to jeopardize the healing and ultimate function of the hand Consequently in forward military hospitals tendon repair is never attempted The underlying structures are treated, the fractures reduced and immobilized, and the soft tissue damage is repaired Tendons and nerves however are not manipulated until six weeks after healing. Proper tendon repair must be performed by a skilled surgeon since irreparable damage may be done by one who does not have a complete knowledge of anatomy or of structures which may be used for graft purposes The surgeon must be willing to spend long hours on the operation, and must give long, attentive, and proper postoperative care until the hand has been correctly rehabilitated. In civilian institutions tendon repairs should be accomplished at the first operation if possible. This is assuming that the patient has had first aid, parenteral antibiotics, that the time is not more than twelve hours after injury and that there is no edema or gross contamination which might contraindicate manipulation. It is hazardous to repair a tendon in a wound which may require covering by graft or in wounds with concomitant fractures As a rule, in wounds of a crushing nature complicated by compound fractures and joint injuries, tendon repair should not be attempted. The lacerated or severed tendon is often located over the sight of fracture and will be become enmeshed, adherent, and fixed within the callus Restoration of the bony structure should be accomplished before definitive tendon repair is attempted. If following initial injury there is a compound fracture, the ends of the several tendons should be tagged, thus making it simple and safe to repair these damaged structures later in a clean, healed wound. In a combat zone

surgical unit, where the wound is first treated *and either left open or under* graft the tendon ends may be transfixed with sutures of stainless steel wire and the ends left long and fastened to the skin for later identification. This information should be written on the cast and on the information sheet accompanying the patient. All divided structures must be identified and the tendon ends numbered and tagged. Nerve differentiation is made by noting the soft, dull-colored structure while the tendon is firm silvery white and contains compact fibers within its sheath The ends may be matched by their corresponding size, shape and anatomical location. Every possible precaution *must* be taken since the end results of tendon repair particularly those which are contained in special sheaths often result in failure even when handled by the best of surgeons Sepsis callus formation surrounding tendon sheaths and excessive suture material, all predispose the area to adhesions and increase the likelihood of failure

The tendon must be approximated without tension and with No 35 or No 36 stainless steel wire sutures In the event the skin laceration fails to parallel the direction of the tendon it is not wise to superimpose a longitudinal incision

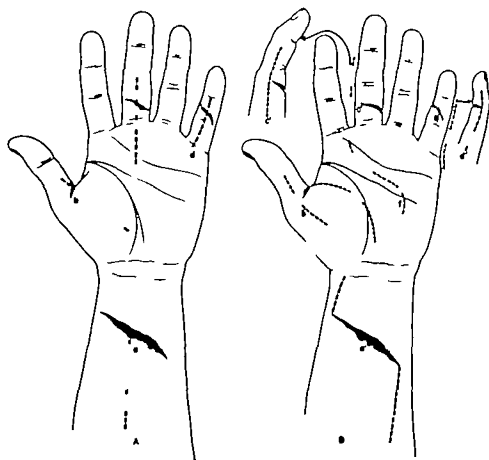


FIG. 5 A. Incorrect incisions for obtaining adequate exposure in treating lacerations. These result in triangular areas of necrosis, T scars, and flexion contractures. B Correct incisions. (Bunnell, S. Surgery of the Hand, p. 612, J B Lippincott & Co., Phila., Pa)

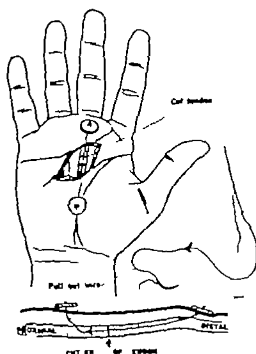


FIG. 25C. Correct serpiginous incisions for obtaining adequate exposure in treating lacerations. (Bunnell, S. Surgery of the Hand p 612, J B Lippincott & Co., Phila., Pa.)

through a transverse wound in order to obtain adequate exposure If exposure is necessary Mason's serpiginous extensions from one or both ends of the transverse laceration should be used (Fig 25B and C) The reasons for this are obvious With an incision through the transverse laceration and in the long axis three triangular areas remain which have a comprised vascular bed, thereby fostering necrosis It is important to stress the fact that there can be no tension at the sight of tendon approximation. If tension is placed upon the suture material it will later break or be extruded. As the tendon heals its sutured ends become gelatinous and lose their power for retaining sutures. The suture line develops little tensile strength until about fourteen days after repair Even then its strength is doubtful for a period of about three weeks It is imperative, therefore, that no tension be placed on the tendon site of repair during this period Care must be exercised so as not to injure or remove the epitenon which is the endothelial covering, or the paratenon—the vascular fatty tissue immediately adjacent to the tendon. If there has been evidence of suppuration in the wound, tendon repair must be delayed for three to five months after healing In this instance, the involved parts are kept active by physical therapy and massage After asepsis has been assured by proper wound cleansing, the tendons should be handled gently and the severed ends isolated and appropriately tagged so there can be no confusion by mistaken anastomosis. The devitalized and jagged portions of the tendon should be removed by sharp excision, always using the scalpel and not the crushing scissors Accurate apposition of the severed ends is then accomplished care being exercised not to twist either the proximal or distal end in its apposition. If a portion of the tendon has been avulsed, an appropriate graft may be made from an accessible but expendable tendon, such as the tendon from the palmaris longus flexor sublimus, or the extensor digitorum communis from any of the three middle toes The transplants are made with the paratenon left in place

To repair loss of *tendon and skin* in lacerated fingers adjacent skin on the dorsum of a digit should be chosen to slide or rotate a covering graft A split thickness graft should then be used to cover the donor site. Areolar tissue should be placed over joint capsule repairs as well as over the site of tendon repair Injured tendons usually heal spontaneously if the paratenon covers the tendon laceration or wound. This however is not true of the tendon within

a synovial sheath. For healing to be effective the part must be immobilized In wounds of the wrist where multiple tendons have been severed it is well to anastomose these tendons The area should be kept completely aseptic, since it has a predisposition to sepsis and drainage if the wound is allowed to remain open It is extremely difficult to provide an adequate split thickness graft for this area as the base will not support its growth, and wounds of the distal *forearm and wrist are difficult to close* later Another hazardous condition exists when a tendon has been lacerated or divided between the distal crease of the palm and the middle crease of the fingers. Any attempt at primary tendon repair in this area is disastrous unless certain maxims of surgery are adhered to There is a narrow tunnel of synovial sheath in this location which thwarts the usual attempt for spontaneous healing In the healing process the epitenon sends tenacled extensions to surround the area of anastomosis It also attaches itself to the surrounding tissues thereby halting any possible chance of motion The movement in the entire hand is then impaired although only one flexor profundus tendon may be involved by adherence If sepsis occurs in this area, the proliferation of the cicatricial attachments becomes so dense that secondary repair is often very difficult Swelling may occur postoperatively within this rather rigid tunnel. This will, in turn lead to tendon ischemia and necrosis with later replacement by contracting cicatrix. No amount of rehabilitation or physical therapy has any effect upon this condition Repair must be done before sixty days, since irreversible muscle shortening will have occurred after this time This same process just described also occurs in the wrist under the annular ligament

Another factor which prevents proper healing within the synovial sheath of the finger is the action of the tendon pulleys which cause sectional constrictions like iron bands around the healing tendon In the process of healing, the tendon has a temporary phase of swelling The tendon swells to more than twice its normal size and distends to the limitation of the bands of the tendon pulleys *and becomes impinged thereby causing* ischemia necrosis, fibrosis, and fixation In the primary repair it is important to remember that the incision of the tendon sheath pulley or the excision of a window in the volar aspect of the sheath over the site of repair is essential.

The next point of importance is the function of the sublimis tendon and its relationship to the flexor digitorum profundus If swelling and fibrosis form the two tendons cannot *slide independently* one upon the surface of the other Consequently in laceration or repair both are jeopardized. To obviate this situation, the sublimis is excised opposite to the joint in this particular zone of danger

Technic· The suture material suggested is No 34 stainless steel wire, braided tantalum wire fine twisted stainless steel wire Fagersta suture, or preferably a barbed wire *tendon suture* consisting of a 30 cm (12-inch) strand of braided tantalum wire Stainless steel or tantalum wire is the only suture recommended in this particular type of surgery because of the absolute necessity for avoiding the addition of any substance which may act as a reactive material or a retainer for bacteria. A core suture of wire may be properly placed to prevent any danger of tissue strangulation, ten

sion or sloughing of the tendon, or the leaving of a portion of suture or knots between the anastomotic ends of the sev ered tendon. The preferred suture is one perfected by Jennings, *et al.*[6] The suture is a 30 cm (12 inch) strand of braided tantalum wire with a single V shaped steel barb affixed eight inches from the straight needle. The straight needle is on the distal end, and the curved needle on the proximal end. The V-points of the barb are affixed like an arrow tip with the arrow pointing toward the curved needle and the two prongs pointing toward the straight needle

After the severed tendon has been cleansed the ends treated with sharp dissection, and approximation accomplished, it is grasped gently between the fingers while the straight needle is threaded through the center of the prox imal tendon segment until the barb has engaged itself The suture is started from 1.25 to 2.5 cm (½ to 1 inch) from the divided end The straight needle is di rected through the midportion of the distal segment for approximately 2.5 cm (1 inch) The straight needle is then brought out to an adaptable site on the skin where adequate tension may be maintained with easy approximation of the severed ends of the tendon. The proximal portion of the tendon suture is then carried through the skin by means of the curved needle. The wire is slid distally then proximally to assure its easy removal at a later date The prox imal end of the tendon is appropriately opposed to the distal end by slight trac tion and the involved finger allowed to

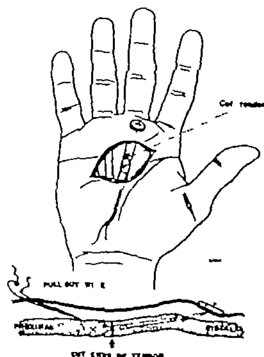


FIG. 26. Showing simplicity of reliev ing tension and approximating the severed tendon ends. The suture is stainless steel wire. The wires may be removed, when the tendon has healed in three weeks, by cutting the wire beneath the button. The wire is removed by withdrawing on the pull-out wire which is looped about the tension wire (Bunnell, S., Surgery of the Hand, J B. Lippincott & Co., Phila., Pa.)

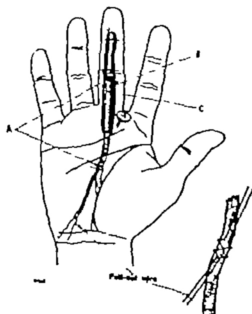


FIG. 27 The suture coming to the sur face proximally is the site of the pull-out wire. A, sublimis removed, B digital synovial sheath split, C, cut tendon.

or elevated on a pillow The splint may be removed in three weeks and gradu ated active movement begun The tendon should also be protected from undue strain and tension.

NERVE INJURY

Lesion Evaluation It is important to obtain a careful and complete history in all injuries of the peripheral nerves as a wound may not be apparent and nerve damage may be secondary to injuries far removed from the hand The actual status of each nerve and the nerve trunks affected is determined before the patient is anesthetized for the operation. The fact that a wound may have been sutured over an unobserved, previous nerve injury should not be overlooked. An examination for nerve injury along the main trunks of the involved structure must be made, since an injury to the brachial plexus may be the answer to the paralyzed hand Constriction or pressure from a tight dressing or cast may also be the etiological factor in the nerve injury If there is an open wound, a very meticulous cleansing and examination of the area should be done The examiner must determine accurately the exact time when numbness or paralysis first occurred or when loss of power was first apparent. The type of wound is impor tant in wounds of entry and exit. A high velocity missile may have a very small wound of entry while practically all the soft tissues in the hand may be literally blown apart.

Reactive or nonreactive zones are noted with the stimulation produced by a needle prick or horsehair· sensory loss to thermal changes is observed by an absence of sweating. Two-point dis crimination by dull and sharp objects, and tests for the vibratory sense are excellent means for scaling the return of nerve function both in wound evaluation and during the recovery phase Radiographic examination must be accomplished routinely from the anteroposterior and lateral views to reveal the possibility of depressed fractures, for eign bodies or other pathological, bony impingement. Although a nerve may appear to be grossly intact, there may be motor and sensory losses due to the sudden trauma, blast, or concussion injury An injury of this type is often diffi cult to evaluate, particularly if no areas of degeneration or softening can be found.

Pathophysiology· After a nerve has been severed or injured severely waller ian degeneration in the peripheral por tion begins almost at once Slow but gradual axis cylinder degeneration en sues with fragmentation and gradual absorption of the myelin sheaths The neurilemmal cells of Schwann gradually proliferate and become dense by fibrosed columnar areas which prohibit regener ation of nerve fibrils. If regeneration occurs fairly early the cells of Schwann act as guideposts to the regenerating nerve Following suture of the severed nerve ends the growth and regenerative changes which occur are those of axon buds reaching out from the proximal stump and growing into the peripheral stump There is a simultaneous proliferation of the cells of Schwann from the peripheral surface. Actually a reduplication of cells and crossing of fibers occurs as this severed gap is spanned. However, if the proximal and distal ends of the nerve are in close apposition, there is less likelihood of reduplication and formation of a proximal neuroma which results secondary to axon over growth. The area of anastomosis may be hypersensitive for from twelve to eighteen months This hypersensitivity is

extend fully without causing separation of the severed ends A small bit of areolar tissue may be placed around the approximated tendon ends for protection and prevention of fixation. After the tendon ends are carefully approximated without undue tension a lead shot or button is used on the skin to maintain the necessary tendon tension for the ensuing three weeks After the tendon has healed, the suture should be freed from the distal shot or button and removed by gentle, steady pulling on the proximal end of the suture.

If there is no direct apposition between the severed ends of the tendon due to avulsion an appropriate graft must be obtained. The same technic is used—the wire being passed through the core of the graft and into the tendinous distal and proximal ends as previously described The lacerated wound edges should be approximated, closed in layers and a dressing applied The wrist is then slightly flexed, with no flexion being maintained in the finger Plaster should be applied to the dorsal aspect of the forearm and hand until adequate splintage is obtained with release of tension on the flexor tendons If barbed wire sutures are not available good results may be obtained by placing a simple wire suture in the same fashion If barbed wire is unobtainable a 25 to 30 cm (10- to 12 inch) strand of No 34 wire with straight needles at both ends may be used The Fagersta suture is one of the most durable of wire sutures. It will not break as a result of friction or bending. This wire may be used as a pull-out wire beginning proximally with each needle going through the tendon, into the core of the tendon, and out the severed end. The proximal tendon is drawn down and approximated The sutures are passed through the core of the distal portion of the tendon, then through the tendon and out through the skin. The two sutures are next tied over a button Attention is then paid to the proximal loop a pull-out wire having been placed at the proximal portion and carried through the skin and left in place The wire should be twisted to prevent the loop from spreading so that no tissue will be caught between the strands A suture similar to this may be employed by placing the wire suture through the proximal portion of the severed tendon. This acts as a lever or a pulley in approximating the distal with the proximal portion of the severed tendon and is known as Bunnell's "pull-out" suture

These sutures are drawn to the correct tension for approximation of the severed tendon and fixed by means of a lead shot or a button. In addition to the pull-out suture, Bunnell[2] effects accurate approximation of the severed tendon ends with the single suture of 00000 silk. After three weeks of healing the distal wires attached to the button are severed and the suture is removed by pulling on the proximal wire or the pull-out wire

Postoperative Care· In splinting and dressing the hand, the fingertips should be kept exposed The dressing may be changed in seven to ten days, and thereafter as needed. Although the hand is immobilized following tenorrhaphy very slight graded, passive motion may be started after fourteen days by the surgeon in charge A fraction movement of the digit will not cause irritation interrupt healing, nor will it prevent the healing tendon from becoming adherent within the sheath To prevent secondary infection, antibiotics should be given regularly for a period of seven days postoperatively The body should be at rest with the hand supported by a sling

or elevated on a pillow The splint may be removed in three weeks and graduated active movement begun The tendon should also be protected from undue strain and tension

NERVE INJURY

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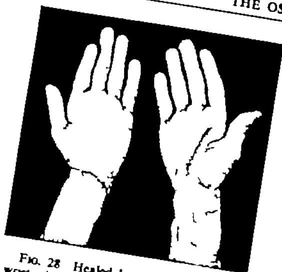


FIG. 28 Healed laceration of the left wrist with a severed median nerve Note the thenar atrophy



FIG. 29B Median nerve laceration showing volar area involved.



FIG. 29A. Median nerve laceration showing dorsal area involved.

due to the budding axons however these soon atrophy and blend into the common nerve sheath and more nearly normal sensation occurs The myelin sheath regenerates until the proximal and distal sheaths are joined

Wound Therapy Wound debridement is accomplished and the lacerated wound treated as previously described

The tendons may be tagged with stainless steel wire sutures for easier isolation at the time of secondary repair The nerves should not be tagged in this manner however nor should the jagged edges be trimmed off They should be cleaned very gently and not dissected from their sheaths as more nerve tissue may be damaged beyond those of the actual wound. The nerve ends should not be approximated (1) when the nerve has sustained an injury or has been severed and the underlying or surrounding tissue devitalized, or (2) when debridement is necessary to the extent that a dead space would otherwise be left surrounding the nerve tissue for the nerve would then be spanning a gap under tension and would be left quite unprotected. If the nerve has been severed by a sharp instrument, approximation and anastomosis may be accomplished at this time

In industrial or civilian injuries where the wound is seen shortly after injury a primary anastomosis of the nerve ends may be done

Nerve injuries in civilian life are as a rule vastly different from the nerve injuries encountered on a battlefield The civilian accident is usually due to machinery sharp instruments or objects such as knives metal, or glass which result in clean incisions These nerve injuries are generally seen from within a few minutes to six hours at the most, so that correct diagnosis exploration, and primary neurorrhaphy can be made promptly

The rules for primary neurorrhaphy are essentially the same as those for primary tenorrhaphy The wound must be clean and fresh The time factor from injury to surgery is decidedly important, since there should be no edema, swelling or gross distortion of tissues This period varies but the most successful primary neurorrhaphy is done within six hours after the initial injury Primary nerve repair as a rule should not be attempted if the wound has been unattended for more than six hours

Cleansing of the wound is accomplished as previously described and every recess entered and thoroughly cleansed. The pneumatic pressure cuff should be placed around the arm and raised to a pressure greater than that of the patient's systolic blood pressure When there is a complicating factor of compound fractures, the bony elements should first be stabilized. If no further manipulation is necessary before healing and the primary closure can be attained, tenorrhaphy and neurorrhaphy if necessary can then be performed at the same time

The nerves of the hands and fingers regenerate remarkably well and any nerve in the periphery in which the surgeon can place the finest of suture, will regenerate It must be borne in mind however that without proper nerve function the muscles will atrophy and



FIG. 30. The left median and ulnar nerves are severed. Illustration shows typical attitude of left hand.



FIG. 31 Involved area following severing of the radial nerve. The hand cannot be hyperextended.



FIG. 32. Bilateral ulnar nerve injury showing areas of sensory loss.

the affected part become useless, regardless of whether or not the bones and tendons have been well repaired. Without proper innervation the part assumes a position of nonfunction and stiffens in this position. The skin becomes easily damaged by thermal injuries. As the weeks continue without nerve function and degeneration continues the muscles atrophy and become fibrosed while the distal portions of the nerves disintegrate and are absorbed. Eighteen months after injury it is useless to suture a previously severed motor nerve. Consequently it is of prime importance that nerves be repaired as soon as possible. Sensory nerves however may be sutured much later and some have been known to regenerate as long as five years after injury.

NEURORRHAPHY

If the patient is in the operating room within six hours after injury primary excision repair and closure in a field of complete asepsis are possible. With gross compounding of fractures or bones causing impingement, and the likelihood of reduction questionable nerve suture should not be attempted primarily but should be delayed until after the wound has healed. If the fracture can be reduced or the fragments of the bone maintained in a position away from the nerve, then all structures should be cared for primarily and the nerve sutured before the wound is closed. If the nerve lesion has occurred following constriction pressure, or traction injuries the individual should be treated conservatively for from twelve to eighteen months. If on examination the nerve appears to be suffering from a blast wound or is partially avulsed, it may be difficult to determine whether recovery without surgery would be possible, or whether it would be better to sever the nerve and anastomose. Conservatism in nerve surgery however is usually the choice.

Nerves like tendons must be handled with extraordinary gentleness. They cannot tolerate being crushed in a forceps or drawn roughly from their sheath. They cannot be rubbed with a sponge nor allowed to dry. A sterile drip of normal saline, or a moistened gauze should be over the wound area at all times allowing freedom only for good operative technic and visualization. In the event the nerve ends cannot be brought in direct apposition, the segments should be gently freed by dissecting both proximally and distally. Several small peripheral nerves arise and branch from the main stem. By careful dissection many of these may be mobilized to allow more freedom of the main or severed trunk. Considerable care and thought should be given before sacrificing these terminal branches. An added slight flexion of the appropriate joints should be allowed to secure apposition and anastomosis of the nerve ends. It may be necessary to transplant the median or the ulnar nerve. This must be done with the utmost care and

these nerves dissected and gently brought forward from the forearm The outer slip of the pronator teres may be severed allowing the median nerve to advance The ulnar nerve can be transplanted from the epicondyle to the groove between the two layers of muscle in the forearm, the brachialis and the biceps. Care must be exercised so that the nerve will not be carried through a muscle, as connective tissue would then form and fibrose the nerve The nerve cannot be transposed to a subcutaneous area, as it would be subject to continuous trauma in this position.

When a portion of the nerve is to be severed it should be done with a razor or a very sharp scalpel. Nerve suturing material should have strong tensile strength and cause a minimum of reaction Catgut, cotton and silk regardless of texture or make-up all have an adverse reaction Tantalum wire 005 affixed to a swedged needle, is the suture of choice Interrupted sutures are placed in a radial fashion in the perineurium The average median nerve takes from six to eight interrupted sutures. Only enough suture to complete the closure should be used The knot should be tied carefully to avoid undue pressure on the nerve bundles and to guard against any possible force being exerted between the proximal and distal ends. The first three sutures should be placed as a triangle with the ends left long and used as a rotator to facilitate the application of the remaining sutures. At all times extreme care should be observed in the handling of the nerve. The position of the nerve should not be altered during the suture nor should the limb be allowed to change in position until it has been immobilized in a plaster cast. If there has been partial avulsion of the nerve and approximation has been attained secondary to flexion the part should be maintained in a flexed position for approximately three weeks Extension is started at this time very gradually but steadily The ultimate time of complete lengthening should be the duration of time it was kept in the cast. Therefore, it should take six or seven weeks to extend a shortened nerve completely Any severed nerve into which a suture can be placed must be repaired The tiny peripheral nerves regenerate quickly and well. Nerves can be sutured to the midportion of the fingers but beyond this point they are usually too small.

Nerve Injuries in Combat

War wounds and civilian wounds from the standpoint of nerve damage and repair cannot be classified very well Most nerve damage in war wounds is the result of the blasting effect of high velocity missiles, while in the great majority of civilian wounds there is no comparable injury

Primary nerve repair as a rule, should not be attempted in military installations at the zone of combat. Wound cleansing and debridement may be performed, but great care should be observed in doing any more than cleansing the nerve Battle casualties are attended by concomitant areas of avulsion, compound fractures of bone, and tissue damage resulting from blast and powder The battle wounds with nerve damage should be cleansed thoroughly penicillin and antitetanus serum administered the wound covered, and the patient sent to a fixed installation with proper facilities for later definitive surgery

The nerve should be kept moist, either by covering the tissues immediately adjacent, or by placing a skin

graft Nerve ends should not be tagged. A nerve however may be approximated by one or two sutures, not with the intention of definitive final-type anastomosis but to prevent the nerve from retracting and fibrosing in an inaccessible area during the interval of wound healing

Every detail of nerve damage must be placed on the patient's record and if a cast is applied, notations of the initial findings should be written on the cast itself The same criteria are used in isolating and determining damage to nerve trunks as are followed in tendon lacerations and other deep lacerating wounds. Wounds of the forearm may involve a major nerve trunk, thus affecting the action of the hand

If the soft tissues are in suitable condition, and if the patient has been sent to a fixed installation with proper facilities final repair and wound healing can be realized within three to six weeks after injury

BONE INJURIES TO THE WRIST AND HAND

Before attempting definitive treatment or repair of the bony structure of the hand there should be a thorough understanding of its composite anatomy The surgeon must have immediate knowledge not only of the entire framework but also of the form and purpose of each bony part, how it fits as a working unit, and how each component is dependent upon the other

Radius Fracture, Extension and Compression Distal End (Colles Fracture)

This fracture is one of the commonest types of extension and compression fractures. The principles of its repair should be well understood since improper handling and reduction can lead to marked impairment of the function of the hand and wrist. This type of injury is much commoner in adults than in children It is usually due to a fall upon the outstretched palm of the hand, or to any type of injury causing a sudden forceful hyperextension of the wrist The pronated hand taking the trauma in this position, forces the carpal bones upward and dorsalward against the radius, thus causing a fracture with frequent displacement of the lower fragment

Incomplete Fracture Distal End of Radius

A fracture in this particular location usually occurs in children and may involve the cortical end of the bone The distal end or the shelf of the bone is displaced proximally and usually causes no noticeable deformity Very little swelling or soft tissue damage occurs There may be a concomitant fracture in the long axis of the radius extending from the articular margin into the shaft. It is unusual for a partial transverse or oblique fracture to occur There may also be an accompanying fracture or slight deformity in the distal end of the ulna

Complete Fracture Through Distal End of Radius

This type of fracture is not uncommon in adults It usually extends transversely or obliquely proximally If it occurs without displacement, the fracture is usually subperiosteal and there is a minimum of damage to the soft tissues If displacement is present it may be classified as a Colles fracture however the fracture is usually approximately 19 mm (¾ inch) from the articular margin The lower fragments are many times comminuted and

may involve the articular surfaces The distortion is caused by the distal fragment being displaced upward and backward with hyperextension on the shaft the articular surface being transposed toward the flexor surface and back As a rule this type of fracture is usually impacted with compression of the cancellous bone There may be an accompanying fracture of the triangular fibrocartilage of the ulna or separation of the styloid process of the ulna. The inferior radioulnar joint may be separated with an anterior displacement of the ulna. In fractures of the distal end of the radius with accompanying displacement there is considerable swelling with extravasation of blood. The swelling may extend throughout the forearm hand and fingers A dangerous complication of this fracture is median nerve involvement, either by compression by the bony fragments or by extreme pressure from the extravasation of blood and swelling of the soft tissues The sensory branch of the radial nerve may be damaged in a similar manner and the transverse carpal ligaments torn There may be a fracture of the posterior articular radial margin in which event there is usually a complete break with upward and backward displacement and a consequent subluxation of the wrist This causes a true fracture dislocation since the carpal bones are displaced upward and backward with the detached marginal portion of the radius This particular type of fracture is called Barton's fracture Another type of fracture is that of the radial styloid, which involves the articular surface This fracture line usually is noted near the middle of the articular surface coursing obliquely and out to the lateral border of the radius approximately 2.5 cm. (1 inch) above the tip of the styloid.

Epiphyseal Separation of the Radius

A separation of the epiphyseal portion of the radius occurs in children and adolescents before the entire bone is solidified. This type of fracture is through the epiphyseal line with displacement of the lower epiphysis and at times involves the cortex of the lower end of the diaphyseal shaft which is fractured and displaced. In many instances the epiphysis may be loosened or fractured without displacement Fracture of the epiphyseal end of bones as well as linear or oblique fractures extending into the articular surface, are provoking from the standpoint of growth stimulation. A fracture into the epiphyseal line or into the articular surface of a joint may cause hemorrhage and growth stimulation which often accounts for one limb being longer than the other

Diagnosis

Many fractures without displacement are not actually diagnosed as fractures, but as acute sprains of the wrist. It is important to compare the wrist joints of both extremities and note whether the point of tenderness is over a line of fracture, over the radial styloid or in the wrist joint itself Pressure over the lateral surface of the radius as well as pressure on the tip of the styloid, will cause pain in fractures of the radial styloid. Crepitation may be elicited with movement of the fracture site The diagnosis of this, as well as all fractures, is confirmed by roentgen study Fractures with displacement are easily diagnosed clinically since there is deformity loss of function, and swelling of the forearm, wrist, hand, and fingers which occur shortly after injury The blood supply of the hand and fingers may be jeopard-

ized either because of pressure from the bony fragments or because of marked swelling In this event the hand becomes cold and distended, and may have varying degrees of cyanosis The pulse may be weak thready or absent It may be impossible to move the hand or fingers if there is a fracture with displacement A silverfork deformity may be quite obvious however after swelling has occurred it may be completely obscured, since the displacement may be entirely toward the dorsum with no backward extension

The dorsum of the injured wrist appears wider than the wrist without injury and the hand is usually deviated slightly to the radial side. This appearance is seen except when the shaft of the ulna has been fractured, or when there has been a disruption of the radioulnar joint with the distal end of the radius being impacted on the cortex of the bone In such an instance there may not be radial deviation and the ulnar head may be less prominent or absent from its normal prominence dorsalward From the volar aspect one may easily outline the head of the ulna with an upward displacement of the thenar eminence Movement of the hand is difficult, especially after swelling has occurred. Generally flexion is provocative of more pain than extension Supination is limited or impossible Palpation will usually reveal the type, degree and extent of displacement, and determine whether it is anterior or posterior ulnar or radial Excruciating point tenderness over any area of the radius or ulna in this portion is quite suggestive of a fracture With obvious deformity and false motion the diagnosis of a fracture of both bones is concluded.

Posterior articulating margin fractures of the distal end of the radius are differentiated from posterior dislocation by palpation of the detached fragment. There is a marked differentiation from the rounded and smooth proximal surfaces of the carpal bones Radial styloid and lateral articulating border fractures are diagnosed by the obvious widening of the wrist, abduction of the hand, and the palpable radial styloid, since the latter is displaced upward and outward

Complications

Fractures of this type are very rarely compounded unless they have been caused by bullets or shell fragments Compounding is usual if the wound has been caused by extreme violence Dislocation of the semilunar bone or carpal fractures may be suffered simultaneously with the radial fracture The sensory branch of the radial nerve is often involved, since it stretches over the displaced lower fragment and consequently may be depressed or lacerated The nerve injury however heals quickly after complete reduction of the bony fragments Blood vessel injuries due to pressure of the bony fragments or secondary to swelling about the radial vessels, are usually of a temporary nature Malunion or nonunion of the bony fragments may be a late complication and may require excision of the free fragment. Traumatic arthritis may be a complicating factor leading to limitation of joint movement. Limitation or painful wrist motion if not due to traumatic arthritis may be secondary to incomplete reduction This is especially true in elderly individuals where healing may be slow If the tendon of the extensor pollicis longus muscle has been lacerated or injured by bony fragments, there may be a spontaneous rupture many months after the original injury Another complication previously mentioned is the fact

that fracture into the articulating surface or into the epiphyseal line with ensuing hemorrhage may stop retard or accelerate subsequent growth Consequently the patient may suffer hand and wrist deformity due to overgrowth, lack of growth or broadening of the fracture site The best assurance against this is adequate reduction with immobilization by a cast.

THERAPY

Fractures Without Displacement All fractures in this location must be reduced regardless of how minor they may seem Fractures of this type involve the joints of both the radius and the ulna, and any displacement may cause marked disability of the hand. After all fragments are in good position, the wrist must be immobilized in an anterior and posterior plaster mold for a period of four weeks. After removal of the mold, the part should be fortified with tape or a leather band until the wrist may be used comfortably without support. The wrist may be supported in the mid-position with slight ulnar deviation of the hand and minimal dorsiflexion. The plaster cast, fiber glass or other type of firm molding should extend from the upper forearm to the base of the fingers and the hand should be in a semiflexed position with a 30 dorsiflexion of the wrist, with slight adduction. The patient may exercise the fingers immediately after the molding has set. A sling should be worn for five days and the hand used in the individual's daily functions

Displaced Fractures of the Distal Radius. All displaced fragments must be replaced in normal anatomical relationship otherwise a proper functioning wrist will not result. These fractures may sometimes be reduced by a strong, skillful, quick manipulation without anesthesia This however is usually unsatisfactory and not advisable Local injection of one per cent novocain, or two per cent xylocaine infiltrated about the fracture site will give satisfactory anesthesia for adequate reduction. The bony fragments may be reduced by strong hyperextension with traction and countertraction until the impacted fragments are freed Strong flexion is then maintained to help dislodge the lower fragment and bring it forward and downward. Simultaneously with the flexion, traction is made upon the distal fragment with downward pressure by the surgeon's thumbs or thenar eminence Countertraction is continually maintained on the forearm with the other hand Most of the motion occurs at the wrist and in the carpal joints, the hand and wrist of the patient being forced downward and sharply flexed to the ulnar side with some deviation. Simultaneous dorsal pressure on the surface of the displaced lower fragment is made by the surgeon's thumbs to force the fragment back into its original position and restore the normal anterior concavity of the distal radius If reduction is complete, the hand will then assume normal flexion. If complete reduction cannot be made by this maneuver it may be necessary to administer general anesthesia. A short acting agent, such as sodium pentothal, may be used for this purpose Reduction may be accomplished by padding and strapping the flexor surface of the arm while the arm is in a flexed position The strap on the arm is then fixed to an immovable object and the patient's wrist grasped by the surgeon's hands, and slow continuous traction with hyperextension maintained to loosen the impaction and affect reduction. As the traction is maintained, the fragments are pulled and

loosened by the surgeon s thumbs while the hand is strongly pronated adducted, and moderately flexed by an assistant The surgeon then strongly presses the distal fragment forward and to the ulnar side while pressing backward with the other fragment to restore the concavity on the volar aspect of the lower portion of the radial shaft. Moderate traction is continued although the reduction may be attained The hand is kept in full pronation, semiflexion and strong ulnar deviation until a cast is applied.

The cast should be placed high on the forearm and should fit skin tight. Some padding may be used for comfort The fingers are allowed to be flexed and active In the event of swelling or anticipated swelling, the cast may be split on the dorsal surface The fingers may be liberated completely in five days to *allow full movement while the cast re*mains in place for six weeks After the cast has been applied a roentgenographic study is made If some flexion of the wrist has been maintained to accomplish full reduction, the cast should be changed in fourteen days and a new cast applied with the wrist in 30° dorsiflexion Roentgen studies are made again to determine the alignment of the fracture with the amount of reduction which has occurred. Complete reduction is assured by noting the ability of the patient to flex the wrist. There is no obvious deformity following manipulation and successful reduction The concavity on the volar aspect of the wrist is within normal limits to sight and palpation

Roentgenographic study of anterior posterior and lateral views must be made after the reduction Attention must be directed to the styloid the articulating surfaces, the radius and the inferior radioulnar joint In the event swelling has been present at the time of reduction the plaster cast is removed in fourteen days and a more closely fitting cast applied In elderly patients or patients with very severe damage to the bones, the plaster cast may be left in position for seven weeks After the cast has been removed daily warm whirlpool or hot baths are given and massage and exercise begun immediately to attain full range of motion

Distal Radius Flexion and Compression Fractures

This fracture is a result of a fall or a blow upon the dorsum of the flexed hand and wrist. It is an unusual occurrence since a person s natural tendency is to hyperextend the hand to receive the blow upon the palm The displacement of the fragment is quite similar to that of the extension fracture except that the distal fragment is displaced forward rather than backward. The diagnosis is made by roentgenographic study It appears as a reverse type of Colles fracture or the opposite of a silver fork deformity There is a marked prominence on the dorsal aspect of the distal end of the upper fragment The wrist is full on the volar surface and there is point tenderness around the end of the radius The radial styloid may be displaced upward and forward and is somewhat pronated There may or may not be actual displacement of the fragments

Therapy In the event of fracture without displacement the wrist is immobilized in the neutral position of dorsiflexion with slight ulnar deviation When there is bony displacement reduction is attained using general or local

anesthesia The method of reduction is the same as described for extension fractures except the proximal fragment is pressed toward the volar surface and the distal fragment toward the dorsal surface to accomplish positive reduction The wrist is placed in the position of hyperflexion to disengage impaction With *continuous traction* applied the wrist is forced upward with ulnar deviation for hyperextension The forearm *and wrist are immobilized in the same* manner as in the extension type

Fracture of Ulnar Styloid

This particular fracture is quite uncommon *It is a* result *of a* fall or trauma received on the ulnar side of the abducted hand which tears off the styloid process The fractured fragment is displaced downward and forward. This type of fracture is very often undiagnosed, as swelling is minimal and there is relatively no disability The pain, however may be severe It is often incorrectly diagnosed as a sprain of the internal lateral ligament of the wrist X rays confirm the true diagnosis

Therapy· Treatment for this condition consists of immobilization of the wrist with the hand in the position of ulnar deviation and slight dorsiflexion *for a period of three to four weeks* The immobilization is accomplished by the application of a light plaster cast of fiber glass or similar material which extends from the upper arm to the base of the fingers with the hand deviated sharply to the ulnar side If pain persists following the removal of the cast, support must be maintained with ulnar deviation for another two to three weeks If there is nonunion and persistent pain the loose bony fragment may be removed

Inferior Radial Ulnar Joint Dislocation

A *dislocation* at *the distal end of the* ulna may occur either dorsalward or volarward A volar dislocation is usually secondary to fracture of the distal end of the radius and occurs when the wrist is in the position of hypersupination A dorsal dislocation also occurs with fracture of the distal end of the radius forcing the wrist to a position of hyperpronation. It is usually secondary to trauma

Diagnosis *The disfigurement at the* distal end of the radius and ulna is usually obvious There is a noticeable prominence on the volar or dorsal aspect *of the wrist beneath the flexor* or extensor tendons depending upon the type of dislocation Because of pain rotation of the wrist is limited or impossible Swelling and tenderness at the distal end of the ulna and radius is marked The wrist may appear narrowed. Roentgen views will confirm the diagnosis and determine whether or not a fracture exists

Therapy· It is usually necessary to administer general anesthesia for this reduction Traction is placed on the hand by the assistant while the hand and wrist are placed in acute lateral deviation The surgeon s thumbs then manipulate the head of the ulna until the neutral position is attained. Following the reduction an unpadded cast is placed from the elbow to the knuckles, and should be well molded around the distal ulna. The cast is left in place for a period of four weeks The hand should be protected for another three weeks and the patient then advised to avoid

rotation of the wrist and to resume normal function gradually

Radiocarpal Dislocations

Dislocation of the radiocarpal area is unusual. However when it does occur the dislocation is toward the dorsal surface with the first row of the carpal bones overriding the dorsum of the radius and ulna. There is usually an accompanying fracture (Barton's fracture) at the distal end of the radius and ulna at the articular margin. The styloid processes may be fractured with the radiocarpal ligaments ruptured or avulsed *with some of the adjacent bone*

Diagnosis. The wrist prominence may resemble a silver fork deformity. It is impossible to move the hand or wrist and swelling, which ensues quickly often masks the deformity. *The forearm* is usually pronated and the hand abducted

Therapy: It is necessary to reduce this type of dislocation as quickly as possible *since the circulation of the* hand is markedly impaired by the tension on the great vessels. A strong traction is placed upon the hand while it is pulled straight upward and down until the carpal bones can be pressed forward over the distal ends of the radius and ulna into the normal position. Any dislodged portions of the bone, such as the styloid process or the radial margin may be molded into place with the surgeon's thumbs. The wrist and forearm are immobilized in a position of slight dorsiflexion with the cast, which remains in place for four weeks extending from the midforearm to the base of the fingers. In the event of anterior dislocation of the radiocarpal joints, firm traction is exerted upon the hand while dorsal pressure is extended on the carpus, simultaneously with the pressure exerted *on the radius, until the contour is* normal. The wrist and forearm are incorporated in a plaster cast as previously described, and the hand immobilized in the neutral position

Fractures of the Carpal Navicular (Scaphoid)

The carpal bones act as buffers between the forearm and hand. The navicular *is the most commonly injured* of the carpal bones and is more subject to the main force transmitted from the hand to the lower end of the radius than are the other carpals. The majority *of fractures of the navicular other than* those resulting from high explosive shells and other types of missiles, are caused by the indirect violence or falls upon the hand

*Pathology: The commonest navicu*lar fracture is that of breaking the body of the bone into two parts by an irregular transverse break near the center and in its long axis. An intra articular *type of fracture is thus sustained* which results in a distortion of the proximal carpal arch. The bone may suffer a comminuted fracture this however is quite unusual as the result of a fall. It is more likely that comminution occurs from a terrific extrinsic force or from the introduction of a missile. The lateral fragment is occasionally displaced posteriorly or the mesial fragment may suffer anterior displacement.

The third type of fracture of the navicular is that of the tuberosity which in reality is an extra-articular type of sprain fracture. The surface of this bone is covered mostly by articular cartilage which, for the exception of small dorsal and lateral portions is relatively avascular. In the event of fracture in the proximal portion of the bone the proximal fragment may lose its vascu-

larity In this event the repair may be delayed from weeks to many months since revascularization is necessary for the healing of the bone

Diagnosis. Every patient with navicular fracture complains of an acute pain in the wrist which is intensified on the radial side The wrist is held rigid and in the position of pronation Because of extreme pain the hand is not capable of grasp or grip Swelling accompanies the acute tenderness of the wrist, and is particularly noted in the anatomic snuff box distal to the radial styloid. Tapping, or pressure in the long axis of the extended thumb causes pain at the specific site of fracture This same maneuver will elicit no exacerbation of pain in the event of sprain Even with limited motion dorsiflexion and radial deviation are painful The diagnosis may be confirmed by x rays The views should be anterioposterior with one view taken while the wrist is dorsiflexed and in the oblique position with ulnar deviation It may be necessary to inspect the film with a magnifying lens to find the small fracture line since there are instances in which the fracture has not been demonstrable until months later when decalcification from the line of fracture has been found.



Fig. 33 Nonunion fracture, right navicular

Therapy Treatment calls for immediate and complete immobilization. Anesthesia is rarely necessary If there is actual displacement of the fragments they are reduced by strong digital pressure and traction An unpadded cast over stockinet is applied from the knuckles to the elbow with the hand in the normal position of slight dorsiflexion and the thumb partly extended. The cast, molded snugly to the palm and about the wrist to insure immobility of the wrist joint, is trimmed adequately to allow full movement of the fingers, but not allowing the metacarpals to be separated from the dorsum of the cast with finger flexion. Fractures of the body of the navicular should remain in a cast eight weeks and fractures of the tuberosity four weeks Roentgen studies are made immediately after removal of the cast and if the fracture has not healed completely a new cast is applied for another six weeks If at the end of this period the fracture still has not healed, the patient is advised to continue active use Fibrous union, however is usually adequate by this time If the cast has been applied while the hand and wrist are swollen, a new cast should be placed when the swelling has receded A cast may be applied for carpal immobilization which will give very little interference with complete digital motion.

Prognosis. If early immobilization is possible, the majority of navicular fractures result in a good functioning wrist. There are some instances however in which the fragments do not unite because of complete devascularization and an ultimate necrotic proximal fragment results When this condition exists, the fragment should be excised early before secondary arthritis develops in the ar

the dislocated carpals by the surgeon's thumbs, reduction is fairly simple With the hand in the mid-dorsiflexed position, a cast is placed on the forearm wrist, and hand up to the knuckles The cast is worn for six weeks after which it is removed and gradually function is restored

Osteitis of the Carpal Bones

Osteitis whether it be from chronic or acute trauma, injury from overuse or of past injury is usually traumatic in origin Osteitis of the lunate bone is also known as Kienböck's disease Osteitis of the navicular is often referred to as Preiser's disease

Diagnosis. The symptoms are those of limitation of motion particularly in dorsiflexion The patient also experiences difficulty in closing the hand tightly because of pain There is a noticeable intermittent dull ache in the wrist which is intensified by movement. Swelling on the dorsum of the wrist may be present and direct pressure over the involved bone causes pain If pain occurs when the middle finger is pushed straight back, forcing the metacarpal against the carpal, a diagnosis of osteitis of the lunate is usually made The diagnosis confirmed by roentgen study reveals osseous condensation with a marked increase in density of the involved bone as compared with the uninvolved carpals Chronic dislocation of long standing may reveal rarefaction or a porous-appearing bone Later it may appear shrunken or broken

Therapy The wrist is immobilized for eight weeks in a circular cast extending from the base of the fingers to the upper third of the forearm Finger exercise is encouraged throughout the entire period of wrist immobilization Roentgenogram study is made and if no improvement is noted the offending bone is removed surgically through a small longitudinal dorsal incision After the bone has been excised and the wound closed and dressed, the wrist and hand are immobilized for fourteen days in 30 dorsiflexion by an anterior splint or cast. When the cast is removed physical therapy and daily exercises are maintained until the hand resumes its normal function If improvement is obvious conservative treatment is continued

CARPAL AND METACARPAL INJURIES

Fractures of the Metacarpal

Fracture of the metacarpal bones is frequent and quite serious, for if it is not adequately treated and allowed to heal properly it will result in great impairment and a hand limited in function. This type of injury is fairly common in prizefighters

Pathology The metacarpals are precisely the same as any of the long bones of the body The weakest portion of these bones, however is just behind the head They are strengthened by strong ligamentous and muscle attachments Consequently when a fracture is sustained there may be some displacement, depending upon the muscle pull. If the fracture is transverse the interosseous muscles exert some tension to direct the metacarpal head forward particularly if the broken ends are in good alignment. In the event of compound comminuted or oblique fractures with displacement due to muscle pull or the force of action causing the fracture the muscles of the fingers pull the distal fragment to the dorsal aspect Usually however it may be pulled to an angle depending upon the amount of tension caused by muscle

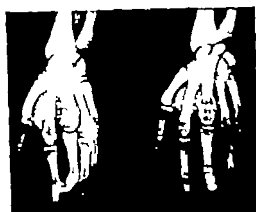


FIG 35 Fracture of third metacarpals.



FIG. 36. Fracture of the third and fourth metacarpals.

insertion. Fractures may be impacted splintered, or transverse however there is usually displacement of the head of the metacarpal forward into the palm.

Diagnosis. The patient may give a history of having heard the bone snap The history of the incurrence of injury the appearance of swelling, ecchymosis and pain will all vary with the type of injury sustained. In fractures of the head or neck of the bone, swelling may quickly obliterate the surface markings of the knuckle Knuckle displacement can usually be seen and palpated by having the patient flex his fingers into a fist. Lateral view of the closed fist may reveal a depressed head of the knuckle obviously below the knuckle line If there are multiple fractures it may be impossible to flex the hand without undue pain, and the fracture site can often be palpated by manipulating with gentle pressure or traction upon the adjacent finger There will always be pain at the site of the fracture whether there is displacement or not. Roentgen views anterior posterior and lateral, will substantiate the diagnosis

General Therapy· If the hand is to function well, the wrist joint must be in good condition. The same applies to the fingers If the fingers are to function correctly it is imperative that the metacarpophalangeal joint is in the best possible functioning position, and in perfect alignment with the rest of the fingers and hand The hand must be kept in perfect balance at all times If the bony framework is in correct anatomical balance the muscles and tendons will maintain this correct balance In fractures of the metacarpals it is essential that accurate apposition be maintained. Over riding of the fracture sites will leave a poorly functioning hand and will result in the fusion of tendons with the bone This one factor more than any other results in crippling from metacarpal fractures The fracture must be aligned correctly and checked by the surgeon moving the finger to determine if full range of motion is possible The alignment of the fingertip should compare accurately with the alignment of the fingertip on the normal hand in the same position For purposes of alignment, fractures must be set as soon as possible to avoid later osteotomies In metacarpal fractures the tendency is for the metacarpal head to be displaced toward the volar surface and the shaft bows dorsally Consequently the metacarpal head assumes a forward position which causes permanent disability and a very



Fig 37 Pin stabilizing fracture of the third metacarpal



Fig 38 Showing how bone graft replacement may be used when the metacarpals have been avulsed

uncomfortable hand. A claw finger results from the malunion of a metacarpal fracture

THERAPY If swelling is present before an attempt is made to reduce the fracture, it may be a handicap Preoperative elevation will aid in the reduction of the edema and general anesthesia such as intravenous sodium pentothal may be necessary The extensor carpi muscles are relaxed by dorsiflexion of the wrist. The interosseus and flexor muscles are relaxed by placing the fingers in the normal position of flexion The knuckles are held in firm traction while steady pressure molding is employed on the dorsal surface of the bone until the ends are brought into apposition and good alignment. A simple method of treating metacarpal fractures is to place a Kirschner wire through the medullary canal in order to transfix the bone A 1 to 1.5 cm (⅜ to ⅝ inch) incision is made over the fracture site on the dorsum of the hand. Gentle retraction is made by means of a vein retractor or nerve hooks and the extensor tendons are pushed to one side and retracted. The Kirschner wire is then placed into the medullary canal of the distal fragment. This is driven through the metacarpal head and out the skin at the *metacarpophalangeal junction* If the fractured ends are fibrosed or there is intervening tissue, this tissue should be removed and the fracture ends freshened The bone is then held in normal apposition allowing no malalignment of the fracture, and the Kirschner wire driven back into the medullary canal of *the proximal fragment until it* reaches the base of the metacarpal It may be necessary to use two or three wires to effect stabilization and accurate approximation of the fragments The wires must never be allowed to enter the wrist joint into the carpals, for if infection occurs it will involve the wrist joint. The wires should be clipped near the skin and completely covered with an air-tight dressing such as collodion to avoid any possible entry of infection. It is important that the fingers and hand be observed closely for any slight deviation in the metacarpals as deviation or rotation will cause overlapping of the fingers when a fist is made if correct apposition has not been attained When good alignment has been assured, the surgical wound should be closed in the usual manner a sterile dressing applied and roentgen pictures made to confirm the bony alignment. No other fixation is necessary Finger motion is encouraged immediately following the operation and the wire removed in two weeks At the end of this time a light dorsal cast should be placed over the forearm, wrist and hand for another two weeks before normal activity is resumed Another method of continued alignment is to

maintain traction after reduction by splinting the hand in a nonpadded cast extending from the knuckles well over the metacarpals, incorporating the palm and the thenar eminence and covering three quarters of the forearm

In order to maintain traction on the metacarpus, a wire or piece of metal is fitted, wheel-shape, into the cast on both volar and dorsal surface. The finger is held in flexion like a bent spoke One small Kirschner wire is put transversely through the distal shaft of the proximal phalanx for elevation, and another through the distal shaft of the *second phalanx for traction extension* With the proximal finger flexed from 20° to 45 the middle joint to 90° and the distal joint to 45 so that the fingers may be maintained in a functional position the Kirschner wires are swung by cords to a fixed point on the wheel of wire. In putting the fine Kirschner wire through the head of the phalanx, care must be exercised so that the joint and the dorsal aponeurosis are avoided. The normal fingers should be moved frequently and extensively by passive motion, and actively as much as is possible without allowing the involved finger to disrupt traction or immobilization.

When the cast is applied to the wrist and hand for a metacarpal fracture a nonpadded cast should be molded *closely* to the conformation of the knuckles metacarpals, and carpals. If swelling is present, the cast must be replaced one or more times to attain a snug fit. To eliminate the swelling, the *hand* and arm should be kept elevated, since swelling may permanently immobilize and cripple the hand Protein precipitates which saturate the muscles and surrounding tissues cause the hand to swell. This fluid forms fibrin which tends to seal all articulating surfaces as well as the tissues themselves Blood vessels then ramify this fibrous mass and later *motion* is difficult. After the hand and arm have been elevated, the hand should be kept moving. Compression dressings with gentle even pressure greatly aid in the prevention of edema.

Fractures Without Displacement

Therapy When the diagnosis of fracture in the metacarpal without displacement of fragments has been established, *it is only necessary to immobilize* the wrist and hand until healing of the fracture has occurred. For fractures of the four finger metacarpals, a simple unpadded, well-molded dorsal cast is



Fig 39 Fracture through third metacarpal neck.



Fig. 40 Fracture stabilization by Kirschner wires.

applied from the knuckles to the midforearm. The wrist is slightly dorsiflexed to relax the extensor carpi muscles The fingers and thumb are allowed to move freely and the cast is held snugly to the volar surface by strapping and bandage *The cast is removed in five weeks* Normal activity however cannot be resumed until the seventh week after injury and if the patient is a boxer boxing cannot be resumed for three months

Fractures Through the Metacarpal Neck

Therapy Fractures through the metacarpal neck usually have volar or lateral angulation. It is difficult to manage the distal fragment because it is short and acts as a marble rotating and displacing itself It is also difficult to manage because of the mobility of the proximal joint. To reduce this fracture it is necessary to flex the proximal joint at a right angle, and the movement of the fracture is actually controlled through the adjacent phalanx A piece of padding may be placed over the middle knuckle, and this joint brought to a right angle The metacarpal is rotated and straightened and by the accurate knuckle alignment it can be determined whether or not it is in place. It may be necessary to disengage an of the fracture if so stron must be employed simultane the elevation of the proximal If there is any difficulty in h proximal piece in place a sma should be made in the skin an ture fixed with stainless steel v a stainless steel Kirchner wir the joint and skin It should re healing has taken place A n cast is applied and the full the dorsum of the involved fin be well-molded to the knuc wrist should be in slight d two-thirds up on the forearm advisable to cast the dorsum of in a position of flexion bringi entirely over the dorsum of and fixing it to the palmar sur cast. If Kirchner wires will fractures in accurate position, not needed. The wires may b off just beneath the skin, a ste ing applied, and the hand kep protection for two weeks The wire is then removed. To hol ture in place properly it may sary to drive the Kirchner wi angles to the bony alignment the metacarpal on either si fractured bone



Fig. 41 Metacarpal fracture with displacement. Fragments may be united by proper application of the Kirschner wire



Fig. 4_ Fracture at base of th metacarpal (Bennett's fractu

Fractures of the Metacarpal of the Thumb

Fracture at Base of the First Metacarpal This fracture is usually caused by a trauma to the end of the thumb or it may be the result of a fall upon the abducted thumb

PATHOLOGY An oblique articular fracture through the base of the thumb is commonly known as Bennett's fracture. Another type, either oblique or transverse and not involving the articular surface is the next commonest condition and is known as epiphyseal separation. Fractures in this portion of the metacarpal tend to displace the distal fragment dorsalward. A true Bennett's fracture is actually a fracture dislocation, since the articulating portion of the fragment on the palmar side remains in its normal position and the base of the metacarpal bone is displaced dorsally over the greater multiangular carpus



FIG. 43 Bennett's fracture with fractures of second, third, and fourth metacarpals.

DIAGNOSIS Acute tenderness and swelling are noted over the proximal end of the bone Due to the dorsal lateral dislocation the deformity is obvious The thumb is powerless and the pain intensified by movement

THERAPY The fracture is treated with the thumb in the position of abduction Unless there is impaction it is usually not necessary to manipulate the fracture very extensively The thumb should be hyperadducted while pressure is maintained upon the base of the metacarpal, and strong traction exerted at the same time A cast is then molded around the thumb the thenar eminence, and the wrist, and the thumb immobilized in the position of abduction The cast includes the entire thumb to insure protection against the possibility of jarring loose the fracture site The fracture site is completely immobilized for a period of four weeks or until x rays reveal good healing. The thumb should be strapped and protected for two to three weeks more and the patient allowed to move the thumb only gradually

If the roentgenograms do not verify reduction and the position is not satisfactory the cast is removed and manipulation repeated. The patient should be questioned within twelve to twenty-four hours as to whether or not there is severe pain at the point of pressure on the dorsum which would suggest an excessive pressure point at that particular area.

Fractures of Phalanges

It is important to know how to care for the single fractured phalanx, since improper treatment of one digit may result in a stiffened, permanently immobilized, and useless hand. A fractured phalanx must never be considered a minor injury This fact is well known to military and industrial surgeons

Pathology Any fracture of the long bones occurs in the phalanges Anything from chip fractures to compounding and complete traumatic amputations can happen In a complete fracture, the

fragments are usually displaced because of muscle pull. In contradistinction to the metacarpal fracture, the phalangeal fracture usually has an anterior depression of the bone at the site of the fracture

Diagnosis The diagnosis of this condition is generally quite obvious Frequently there is deformity and throbbing pain, and the finger becomes swollen, tense, and may become ecchymotic. Pressure exerted on the tip of the finger may reveal the fracture site as the point of greatest pain False motion and crepitus may be noted. The diagnosis will be confirmed by the roentgen rays

Therapy If there is no displacement of the fragments the finger may be placed in an aluminum finger cast which will immobilize the part in the position of semiflexion and act as a protective support This may be left in place until the fracture unites Displaced fractures may be manipulated into good position without anesthesia, but as a general rule it is better to use a good local or general anesthesia In approximating the fracture ends traction may be the method of choice This method, however is very often used incorrectly If traction is placed in the anteroposterior direction the matrix or nail bed may be disrupted and the nail pulled off, thus causing considerable pain If the wire or tension is placed laterally great care should be observed so that it will not be put through the flexor or extensor tendons If the pin is placed through the pulp it may be pulled directly and easily through the pulp Adhesive traction on the skin is usually sufficient, because the traction need not be very strong. The finger should never be dressed straight, nor should the traction be exerted on the extended phalanx, as the tendon is thus pulled in the same direction causing the finger to stiffen accordingly Stiffening and spreading of the fingers occurs when the banjo splint is used. This splint makes it difficult if not impossible to regain a well-functioning hand If only one phalange is fractured, then it alone should be immobilized the other fingers should be free at all times and the patient encouraged to move them.

Fractures of the proximal and middle phalanges are reduced by manual molding. If traction is needed to sustain this reduction, the fingers should be held under traction in a semiflexed position and a pliable wire extension applied. Bohler has a very excellent type of aluminum splint for phalangeal fractures in which the splint fits around the wrist like a cuff, and a grooved brace courses up the midportion of the palm and down past the tip of the finger holding it in a normal position of flexion Pulp or bone extension traction may be maintained by wire When the proximal phalanx is fractured, the proximal joint should be placed at an angle of approximately 45 the middle phalanx at 90 and the distal phalanx at 45° The normal position pointing of the nail in the opposite hand can serve as the best guide for the rotation and directional plane of the flexion cast in which the finger should be placed. If the middle phalanx is fractured proximally to the sublimis insertion the proximal fragment is extended by the extensor tendon as it fits into the base If the middle phalanx is fractured distal to the sublimis insertion, the proximal fragment is then flexed, due to the action of the flexor sublimis which is attached at the midportion of the phalanx. The fracture is reduced by molding and traction. In the splinting of phalangeal fractures a three-quarter forearm cast covers the

wrist and the digital volar aspect. Aluminum extension may then be used as a curved gutter splint and strapped to the finger with the straight portion crossing the proximal fracture.

Fracture of the distal phalanx may be more painful than any other type of fracture in the phalanges as there may be a hematoma which because of the wooden or aluminum metal splint is sufficient to hold the fracture in good alignment. If a chip fracture has occurred on the distal phalanx pain and tenderness will continue If the condition persists and there is nonunion of the fragments, the small detached fragment may be removed by tiny lateral incision and the wound closed without drainage

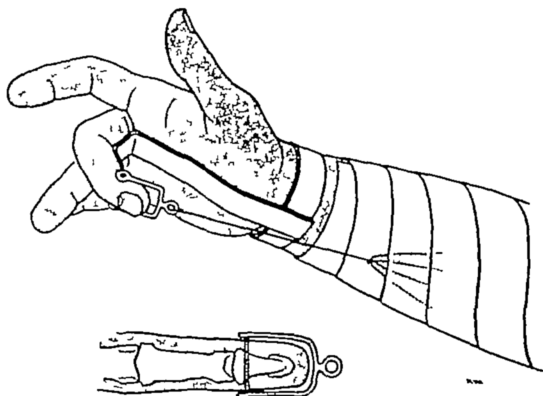


FIG. 44 Illustration showing application of aluminum splint and traction for phalangeal fracture.

pressure in the closed pulp space, results in a swollen, tense throbbing fingertip This may lead to edema and avascular necrosis Pain may be relieved by boring or cutting a small area in the nail bed and allowing the blood in the hematoma to escape This is done under strict asepsis to prevent any possible infection If there is an exit for the hemorrhage incident to the fracture pain and swelling rapidly disappear Immobilization of the finger in a straight

Drop Finger (Mallet or Baseball Finger)

This condition is the result of partial or complete avulsion of the extensor tendon from its insertion in the base of the terminal phalanx. A small piece of bone may be avulsed with the tendon, secondary to the force which has struck the end of the extended finger causing sharp flexion against resistance of the extensor tendon The terminal phalanx is movable but is held in the flexed posi-

first measures to be undertaken. This form of therapy should be continued later in conjunction with hydrotherapy electrotherapy and exercise

Beginning massage is systematized in a pattern first massaging the arm and forearm muscles in the centripetal direction to facilitate the vascular flow Moderate pressure is used with care so as not to bruise or pain the patient, and not to massage any tender healing areas Gentle kneading is then employed on the individual structures of the hand Massage is beneficial during or immediately following application of heat from infra red or diathermy

Electrotherapy: Electrotherapeutic measures may be initiated early and before hydrotherapy Diathermy is an excellent method to stimulate the vascular network of an injured part.

Atrophy of a muscle occurs gradually with disease consequently galvanic and faradic stimulation is of value The muscle is stimulated to contraction thereby increasing the vascular flow While the galvanic current stimulates the muscle the faradic current contracts the muscle by nerve stimulation This type of stimulation should never cause pain and is best done in beginning stimulating doses of five times per minute and gradually increasing the number and duration of treatments commensurate with the healing of the wound and adaptability of the patient.

Hydrotherapy: When the wound has been sufficiently healed, hot arm baths three or four times daily are very beneficial to the patient

The circulation is improved and motion is accomplished much easier and more readily The hand and forearm should be immersed into a bath alternately with temperatures of 110 F (43.3 C) and of 60 F (15.5 C) thereby giving the contrast effect of vasodilatation and vasoconstriction of the vascular system Whirlpool baths are beneficial and will expedite healing The hand and forearm are immersed in the whirlpool bath at a temperature of 105 to 110 F (40 6 to 43 3 C.) for a period of thirty minutes at each time of therapy

Massage should follow each treatment with heat or hydrotherapy If joint adhesions are present they may be gently broken by passive motion and the part should be moved through as complete range of motion within pain limitation This massage and motion is repeated daily

Exercise Active exercise is done by the patient as soon as possible and on a graduated basis The patient is directed as to the types of exercise necessary to exercise properly all hand and finger muscles Glass beads, sand or beans may be used, and the patient is exercised by picking up the object between the fingers for a few minutes every hour of the day The appropriate exercises are used to coincide with the type of malfunction present. To exercise the muscles of the hand, gripping devices are used, such as soft rubber balls in graduated sizes These may be used until the patient is actually capable of using a spring gripper The interossei are exercised by active and passive resistance and by picking up objects The hand may be placed in a container of sand with the fingers abducted The patient is then directed to pick up as much sand as possible between the adducted fingers while he raises his hand Sand or other objects are used for the thumb and little finger If increased flexion is needed, the individual may dig with the fingers or various types of spring exercises may be used. A de of

pulleys connected to a stationary object may be made into a suitable exerciser A spring strong enough to allow for good finger exercise is connected to a band into which the tip of the finger may fit thereby allowing for resistance exercise Various types of exercises can be taught with little ingenuity Enjoyable occupational therapy is that of making hook rugs or participating in needle work or knitting as this will increase the interest of the patient and at the same time he will be making some useful object.

Deformities Hand deformities are corrected after complete and thorough trial of physical therapy If the limb does then not function properly various types of splinting may then be employed however the most expedient may be surgical intervention for reconstructive repair and possible tendon transplantation

(I wish to express my gratitude to Edwin J Pulaski, Colonel, M.C., U.S.A., and to Ray L. Miller Major M C., U.S.A., for their help in review and correction of this Chapter)

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Athletic Injuries

THROUGHOUT the seasons of the year many individuals engaged in competitive sports become the victims of major and minor injuries Some of these injuries are sufficiently severe to result in death The outstanding American sports in which severe injuries may occur are boxing, football, baseball, basketball hockey and track. Of all the sports mentioned, boxing in recent years is associated with the highest mortality and the more serious types of injuries.

These boxing injuries may be minor cuts and bruises or a severe head injury resulting in death Since the boxer is exposed to his opponent's blows directed to the head neck, thorax, epigastrium and upper extremities these regions fall victim to local injuries The more critical injuries are those produced in the head. Serious acute hemorrhage or repeated petechial hemorrhages of the brain may prove fatal to a boxer Injuries to the other regions of the body are usually nonfatal. The various injuries sustained by boxers are discussed under their respective headings in this book.

Injuries to boxers are sufficiently serious to warrant special concern of the *Boxing Commission in many states In* some a boxer is forbidden to fight again until thirty days have elapsed following a major injury This policy is a precautionary measure and a valuable prophylactic procedure against a fatal injury

Other sports produce injuries which can be mentioned collectively and are discussed elsewhere in the various chapters of this text However it is instructive to mention certain general aspects of infections as seen in athletes It has been the sad experience of surgeons that athletes tolerate infections very poorly This is true even with the availability of antibiotic therapy

It is strange to relate that in this era of surgical advancement wherein we have seen a diminution in mortality resulting from infections that apparently young men in visible excellent health succumb to infections of variable severity The diminished resistance to infection on the part of athletes is not an unknown fact. An outstanding example of this some years ago was the death of a U S president's son from septicemia following a foot infection incurred while playing tennis This occurred years before the advent of the antibiotics When death continues to follow the path of athletes in spite of adequate antibiotic therapy the cause for failure must be *sought in the patient himself*

This intrinsic failure may be due to one of three factors or a combination of two or all three These factors are

1 The constant state of elevated basal metabolism due to excessive physical activity

2 The absence of a general reserve capacity to combat infection Apparently the normal reserve capacity is consumed by the athlete during the constant period of training.

3 The presence of an enlarged thymus gland which results in a pathologic state similar to status thymus lymphaticus

Young men actively engaged in strenuous competitive sports must prepare themselves for these activities over a long period of training. This constant state of physical activity "burns up" the human body to such a degree that it is always in a hypermetabolic state Thus, the normal metabolic state of an athlete in comparison to a similar non-athlete is in reality a hypermetabolic state.

This continuous hypermetabolism consumes any reserve capacity which is part of the normal physiology of the average individual. Thus when the athlete becomes the victim of an infection he has no reserve with which to combat the infection. Although the antibiotics have been a great aid in the fight against infection, nevertheless the patient's bodily response is an important adjuvant in this battle If the immunological response to infection is absent, the antibiotics alone are ineffectual.

At autopsies performed upon athletes the thymus gland has been found to be much larger than that encountered in routine adult autopsies The physiology of the thymus gland in this regard is not known. It seems to be confusing since thymectomy found many advocates in the treatment of myasthenia gravis Perhaps some future investigator will unfold the answer to this relationship

As a general statement, it may be said that athletic injuries fall into several categories namely into those of the skin muscles ligaments and joints Fractures occur in the baseball player and the basketball player Fractures are relatively rare in football This is surprising when one considers the hard tackling in the game The injuries vary in type from a slight abrasion to compound injuries Athletes who sustain any type of muscle joint or ligament injuries should always be put at rest for twenty-four hours and then the injury re-evaluated prior to the next game

One of the commonest complaints of athletes is bursitis The most disabling and serious bursitis is that of the subdeltoid bursa of the shoulder This is frequently seen in baseball pitchers The onset of bursitis may follow a common cold or an infection elsewhere in the body It may be a complication of circulatory or another disease It may arise as a complication of some other malfunction in or about the shoulder joint. This subject is treated more extensively in Chapters 37 and 44

Muscle injuries are frequently encountered in the athlete "Pulled" muscle is a rupture of some fibers of the muscle with or without a tear of the sheath that surrounds it. The symptoms are localized pain in the affected muscle with an inability to run, hit, or kick a ball. It occurs most often in the rectus femoris (football) and the biceps (baseball) muscles Little definitive treatment is available for this type of injury Rest is essential and too vigorous massage or other physical therapy delays rather than hastens recovery The application of heat with gentle active motion without the production of pain is the first stage of treatment. Activity is limited within the sphere

of painless actions Recovery is very slow and may prevent the player from returning to the athletic field for several weeks (about three weeks)

A second muscle injury of athletic origin is intramuscular hematoma This is not an uncommon injury It may result from either a kick a collision with another player or from a fall on hard ground Aspiration of the hematoma is not the best therapy The injured player is not allowed to play again until all physical evidence of the hematoma has disappeared. Calcification in a hematoma is a complication which may cause serious disability and which may require excision of the calcified mass

An incapacitating entity is myositis ossificans It can occur in the adductor or quadriceps group and may become so extensive that movement at the hip or knee is seriously impaired. It results following repeated strains causing rupture of muscle fibers and intramuscular hemorrhage and may develop slowly over several years Excision often is necessary A progression of this condition will eventually force the victim to retire from the athletic field An unusual and most painful injury seen in football players is the development of a painful fibrous mass in front of the tendo achillis When it does occur surgical removal will allow the player to return to the game

In the treatment of athletes especially the baseball football and boxing group it is extremely important to treat the emotional and psychological background of the injury The vast publicity given to these groups of athletes has made their names popular in many homes and as familiar as those of the theater and the cinema Moreover the members of a team fully realize that their performances will be the subject of discussion among their fans In this fashion these athletic exhibitions have become a combination of sport and show business which makes the athlete as sensitive to the reactions of the public as is the film star It is not unusual for an athlete after an injury in his first game to express his anxiety about "letting down his fans"

Professional athletes are conscious of the fact that the quality of their playing may be impaired after an injury This may result in an anxiety which leads the player to fear that his contract may not be renewed at the end of the season In other instances especially in men approaching the end of their athletic careers there is a tendency for the player to attribute to a recent injury a loss of speed or other disability with which it has no connection

For these reasons an athlete even more so than the average patient, must be considered as a psychosomatic entity Nothing is more disheartening to see than an outstanding athlete whose morale has been broken through injury or mental anguish A little psychosomatic approach to the surgical injury often is sufficient to restore confidence to the athlete whose injuries have given him a mental shock.

JOHN G McNAMARA, M D

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Acute Osteomyelitis

History: Discoveries too numerous *to mention* reported by archeologists and anthropologists have revealed to us that bone infection in one form or another has existed from the time of the earliest humans This disclosure of antiquity is not difficult to understand when one considers that osseous tissue because of its distinctively dense anatomical structure, is naturally more resistant to destruction and therefore the last of the body tissues to fall victim to eventual decay However more accurate scientific knowledge of bone disease has come into our possession only within comparatively recent years The first person believed to have employed the term osteomyelitis in medical literature was Nelaton[1] about the middle of the last century In the light of our present knowledge, this word has proved to be a most accurate and descriptive one, inasmuch as we now understand that acute inflammation of bone involves all the structures which comprise osseous tissue For centuries prior to the last one, numerous accounts of bone infection have been reported and recommendations for treatment recorded. Originally only simple incision and drainage were advised, but even some very early authors suggested and performed sequestrectomy when indicated.

Etiology Acute osteomyelitis is an acute pyogenic infection of bone of hematogenous origin in at least ninety per cent of all cases the remaining ten per cent stemming from direct trauma as in compound fractures or occasionally arising as a postoperative complication It is a general consensus[*] based upon bacteriological investigation, that in the vast majority of instances the invading organism is some strain of the staphylococcus group Exceptions to this are not infrequently encountered in very young children wherein streptococci have been demonstrated, but much less often the bacterial invaders may be pneumococci gonococci, or the typhoid bacillus

Distribution Neither race nor sex appears to constitute any appreciable factor in the occurrence of acute osteomyelitis, but age does because it is a well established fact that most of the victims are children. Reasons for this seeming specificity will become apparent later Any part of the skeletal system may be attacked but most lesions are found in the metaphyses of long bones Phemister advances as a reason for this apparent selectivity the observation that the more abundant blood supply found in these areas of rapid growth offers an easy portal of entry Substantiation of this claim appears fairly certain when

the incidence of involvement of the lower end of the femur with its rich blood supply is compared to the less frequent infections at the upper end Similarly when the tibia and humerus are affected, the regions most often attacked are the more highly vascular upper areas Histological studies of these *juxta epiphyseal regions* reveal their relatively high vascularity and offer additional confirmation of this hypothesis

Pathology The invading organism in the hematogenous type of infection reaches the bone by way of the nutrient arteries, but in order to establish an area of infection of any consequence, the invasion must be in large numbers and of considerable virulence [3] The opposite of this, namely few invaders of low virulence might conceivably result in conditions which we now classify as "aseptic necroses " the absence of positive smears and cultures being attributable to the fact that the body overcame the infection but that the circulatory embarrassment persisted When the infectious material reaches its ultimate destination, the immediate result is the formation of one or more minute septic thrombi, thus depriving these areas of their blood supply and bringing about localized areas of necroses In quick succession this is followed by hyperemia round cell and polymorphonuclear infiltration, and the catabolic action of proteolytic enzymes all contributing to the formation of an exudate which at first is somewhat serous in nature but gradually becomes more purulent as the destructive process increases. As the activity within the bone progresses the intraosseous pressure becomes more pronounced, more bone is destroyed abscess formation occurs, and eventually the cortex is penetrated, leading to the invasion of the sub- and extraperiosteal areas Subsequently if a considerable amount of bone is affected portions of it completely deprived of their blood supply may remain unabsorbed and thus form what are commonly termed sequestra.

Symptomatology Widespread differences in early symptoms may occur depending to a large extent upon the age of the patient, location of the lesion the individual's resistance, and early treatment. In general, careful questioning will elicit information of an earlier illness a penetrating wound, or some mild skin infection already cleared up In children particularly the onset may be very abrupt and severe commencing with chills pain headache and rise in temperature and pulse rate. In adults general malaise may be the earliest symptom followed later by local findings Eventually pain is the predominant feature varying considerably in degree, but invariably accompanied by restriction of motion of the affected part and an acute exacerbation of the pain if passive motion is attempted Tenderness and increase in skin temperature occur early and are followed by swelling and ecchymosis

Laboratory Findings. Routine blood examinations during the early stage of infection usually show an elevated white cell count with a marked increase in the number of polymorphonuclear leukocytes together with a sharp and definite increase in the sedimentation rate A blood culture taken at this time is more likely to be positive than later and if so may offer considerable aid in determining the most effective antibiotic treatment.

Roentgenograms In the very early stages, x-rays offer little or no help because there has not been sufficient al-

teration of the osseous structures to produce abnormalities on the films but the presence of soft tissue swelling should at least arouse a suspicion of underlying bone involvement. A negative x-ray report in early cases does not rule out the possibility of osteomyelitis, but delaying until positive roentgenographic evidence is present and using antibiotics in the interim is not nearly so dangerous as heretofore

Treatment Fortunately for both the physician and the patient especially the latter recent advances have produced many helpful aids in the treatment of this formerly crippling and frequently fatal disease Beginning with the sulfonamides and progressing on through the various mold derivatives we now have at our disposal a large variety of ancillary substances Before discussing these newer adjuncts it is well to review the advantages to be gained from the use of physiological methods Of paramount importance is the necessity of instituting physiological rest of the affected member so that first of all, pain may be relieved, and secondly that in some slight degree at least, local progress of the infection may be retarded pending further investigative measures and more definitive treatment Depending upon the location of the lesion, complete or partial immobilization may be employed Thus, in the lower extremity simple Bucks extension or a Thomas splint may prove helpful whereas for immobilization of an upper extremity a Thomas arm splint or loose strapping to the chest may suffice Next in order of treatment are the antibiotics If a positive blood culture has been obtained, the use of *in vitro* laboratory tests should indicate quickly the proper antibiotic for treatment. Theoretically this procedure is sound, but as pointed out in a recent editorial in the Journal of the American Medical Association it has many practical limitations inasmuch as clinical results and laboratory tests do not always coincide This editorial further states that since Group A streptococci pneumococci, and gonococci are more or less uniformly responsive to certain antibiotics treatment may be instituted without resort to sensitivity tests Furthermore, since most infections are caused by some strain of staphylococci, the administration of penicillin pending more accurate tests may be of considerable help To rely upon antibiotic therapy alone in the treatment of osteomyelitis is fraught with considerable danger in many instances Investigators[4] have shown wide ranges of reactions even under the most stable conditions, but they have demonstrated however that discrepancies were least frequent with penicillin. It would seem logical, therefore that the most effective form of treatment would resolve itself into a combination of physiological, antibiotic, and surgical measures There is no question but that surgical treatment has been made much safer and more effective when combined with chemotherapy However inasmuch as osteomyelitic infection results in the formation of a bone abscess that pathological condition calls for drainage just the same as a soft tissue abscess does, so as to lessen further damage and hasten recovery Surgical decompression as performed over the years has run the gamut from simple drilling to wide excision. Neither extreme has proved satisfactory the former because drainage is inadequate and the latter because it is unnecessary and results in prolonging convalescence It has now been fairly well determined that the removal of a

moderate but adequate portion of entire cortical thickness offers the best results The wound is left open and, if feasible fine catheters may be inserted into its depths and held in place by petrolatum gauze so that local instillations of the antibiotic of choice may be *carried on in conjunction with its systemic administration* Postoperative immobilization is also a necessity for reasons mentioned previously and the value of blood transfusions should not be forgotten. Infrequent changes of dressing are in order so that the healing process may not be retarded by reason of destruction of granulation tissue It is much safer and surer to allow the catheters and packing to be extruded spontaneously this being the best indication of the absence of pocketing The treatment just outlined is in general a satisfactory one and in instances where it has been indicated, has made it possible to perform secondary closure much sooner than it could have been done prior to the local and systemic use of the antibiotics

Prognosis. Flare ups of old osteomyelitic infections are common, so a *prognosis should be guarded* Because of chemo- and antibiotic therapy however the frequency of both early and late metastases appears to be diminishing, and for the same reason reactivation of the original lesion has become much more amenable to conservative treatment.

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Emergency Neuromuscular Disorders Treated by Regional Anesthesia (Nerve Block)

Introduction Regional anesthesia is most often only an adjunct to other therapy If a patient in pain may be relieved by other therapeutic measures it is seldom necessary to resort to nerve block unless the only alternative relief lies in continual use of narcotic drugs This, of course applies to nerve block, *per se* and is not to be construed as applicable to injections of procaine for the eradication of trigger areas in muscles or the use of ethyl chloride sprays for the same purpose, where semipermanent neurolysis is not the primary objective. The more easily performed procedures and only the more salient points in the anatomy of the nervous system and their relationship to other structures will be presented in this limited exposition.

Needles and Syringes. Two or 5 cc. syringes and an assortment of needles of various lengths and calibers are all that are required by way of equipment. A small piece of rubber tubing (about 1 sq cm) is used as a *recorder* or *marker* to gauge the depth of the needle and is useful The recorder is fitted to the needle by passing the needle through the center of it. In the descriptions of the block procedures, needle lengths and gauges and the use of the recorder will be dealt with in detail

Anesthetic Agents. Procaine (ester of beta diethylamino ethanol)—½ 1 1½ and 2 per cent solutions are most often used

Pontocaine — 0 15 to 1 per cent (monobutylamino benzoic acid ester of diethylamino ethanol)

Oil solutions are seldom used now since the utility of efocaine became evident. Efocaine* is a clear nonoily water miscible solution which will produce an anesthesia of approximately six to fourteen days (others only for a few hours to four or five days) It is a solution of procaine 1 per cent, procaine hydrochloride 0.25 per cent, butyl-p-aminobenzoate five per cent, in a solvent composed of polyethylene glycol 300 two per cent, propylene glycol, seventy-eight per cent, and water It contains no vasoconstrictors Its mechanism of action is based on the fact that substances which are not water sol-

*The trade mark of E. Fougera of New York.

uble are slowly absorbed from the tissues Procaine and butyl-aminobenzoate are not water soluble but are readily soluble in propylene glycol and poly ethylene glycol-300 When this combination is injected into the tissues the tissue fluids (lymph, extracellular fluid, etc) cause the anesthetic agents to be deposited in a crystalline form These depots are then slowly absorbed to produce a prolonged anesthesia over the area of their distribution.

Alcohol—twenty fifty and ninety five per cent. It is a most powerful neurolytic agent and should be used with caution It is most often useful in blocks about the head. It often causes an alcoholic neuritis which is worse than the original condition particularly in para vertebral and intercostal blocks It is however the only neurolytic agent available that will produce the desired anesthesia for weeks months, or years, according to the volume used and the accuracy of placement of the solution into or near the nerve structures and the ability of the nerve to take up the agent.

Recently six per cent phenol has been reported as useful in nerve block therapy The writer has had no experience with this agent

Premedication In general, when using procaine or similar drugs a preliminary dose of one of the short acting barbiturates should be administered. If given orally the dose should be taken one to two hours before the injection if subcutaneous at least one half hour before Nembutal, seconal, or amytal, 0 1 to 0.2 Gm (1½ to 3 grains) is usually employed It is important not to use narcotics when blocking for painful conditions as these drugs disguise any relief obtained and render estimation of the efficacy of the block difficult. Where the operator has other signs to guide him (*e.g* in stellate block with resultant Horner s syndrome or lumbar sympathetic block with temperature changes in the feet) a small dose of narcotic (morphine sulfate 10 mg or grain 1/6) may be administered an hour before the procedure for the sake of the patient s comfort.

NERVE BLOCKS ABOUT THE HEAD

Only the commonest conditions and easier procedures will be considered. Trigeminal neuralgia or tic doloreaux is an affliction of the trigeminal nerve in one, two or three of its branches namely ophthalmic, maxillary or mandibular tic This is one of the classical pains of medicine and the sufferers from true tic are worthy of effective relief The gasserian ganglion may be blocked either laterally or anteriorly by the methods of Labat In experienced hands, these blocks done with procaine and ninety five per alcohol are most efficacious in relieving the intense pain passing over one or all of the branches of the trigeminal nerve However the inexperienced may try a more or less effective method which is not difficult to accomplish. Usually one branch of the nerve is more affected than the others or one branch is affected alone The three foramina of the skull transmit these nerves to the surface of the face They are the supraorbital foramen which transmits the supraorbital nerve (first division of the trigeminal) the infraorbital foramen transmitting the maxillary nerve (second division) and the mental foramen transmitting the mental nerve (third division) All these foramina lie in the same plane at a distance of 2.5 cm (1 inch) lateral to the midplane of the face (Fig. 1) Pain-

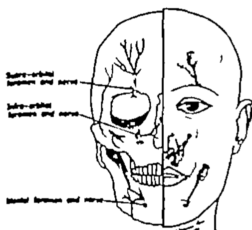


FIG. 1 Blocking of the terminal branches of the gasserian ganglion. The three foramina of the skull supraorbital, infraorbital and mental which transmit their respective nerves for cutaneous innervation. The foramina lie in the same plane 2.5 cm. from midplane of the skull. Anesthetic injections may be made into the foramina or in close proximity to them. Stippled areas indicate zones of analgesia resulting from block of each nerve

ful affections of these branches may often be controlled by simple novocain or efocaine injections into the nerves at their respective formina. The supraorbital may easily be palpated by inserting the finger of one hand into the supraorbital notch. A wheal is placed at this point and a small needle introduced through the wheal until bone is contacted. A few movements of the needle will elicit parasthesias along the course of this nerve namely cephalad over the forehead and scalp as far back as the saggital suture It has been found in many cases that merely interrupting pain impulses temporarily with novocain in this manner will give prolonged relief It may however be necessary to do it more often. When efocaine is employed the resulting anesthesia may be prolonged for ten days or more The block is useful also in surgery of the fore head and anterior portion of the scalp e g suturing lacerations, particularly in children Maxillary tic may be controlled by injections into the infraorbital fora men or into the region of the foramen. The foramen is easily palpated opposite the ala of the nose on a plane with the pupil of the eye The foramen is located in the canine fossa and by pressure over it, painful parasthesias may be felt by the patient. The foramen runs upward from this point and outward at an angle of twenty five degrees and communi cates directly with the orbit. Hence only small amounts of solutions should be injected (to 2 cc) because of the possibility of causing edema of the orbit. If it is not possible to find the foramen with the needle the procaine solution may be deposited near it in the region of the maxilla and the area massaged. Resulting anesthesia will include the upper lip and the side of the nose If the solution is injected into the foramen, the upper front teeth will be anesthetized (anterior alveolar plexus) The mental nerve may be palpated externally by locating the first and second bicuspid and running the finger downward on the surface of the skin to the center of the origin of the teeth in the mandible A short distance, about 5 to 7.5 mm., below this point the foramen is located and novocain may be injected in this area after first contacting the substance of the mandibular bone This will give anesthesia of the lower lip and some times of the gum and front teeth of the same side

Banthine (methantheline bromide) has been found useful in the treatment of trigeminal neuritis. It is usually administered in 100 mg. doses every six hours This gives relief for six to seven hours following which the pain returns following trigger movements The ra tionale is thought to be on the basis of

the action of banthine as a depressant of acetyl choline mediated nerves It depresses the sympathetic system at the preganglionic endings and both the sympathetic and the parasympathetic systems at the postganglionic endings. So little is known about the composition of the gasserian ganglion and its central connections that it may have a rational basis for use in trigeminal neuralgia, although the gasserian ganglion is not classified with the parasympathetic system The writer has had two cases in which it was dramatically effective It was tried in tic doloreaux because it may inhibit afferent stimuli through the gasserian ganglion. In another case reported by Stitch, it had this effect and abolished the pain (and trigger points) It may be effective in other neuralgias.

Temporal Artery Neuralgia The anterior deep temporal nerve is a branch of the mandibular nerve The superficial temporal nerve is a branch of the auriculotemporal nerve which supplies the skin of the temporal region and anastomizes with the temporal branch of the facial nerve The superficial temporal artery is the smaller of the two terminal divisions of the external carotid artery It is often considered a direct continuation of the external carotid It ascends and crosses the zygoma being accompanied by the superficial temporal nerve which lies beneath and usually a little behind it. It is surrounded by a dense plexus of sympathetic nerves Temporal neuralgia may occur idiopathically or from trauma and may be relieved by two per cent procaine two per cent xylocaine or efocaine injections about the temporal artery which will block the superficial temporal nerve and the sympathetic plexus The *technic* is simple Palpate the temporal artery in front of the pinna and with the point of the needle just under the skin and near the artery deposit 2 to 3 cc. of solution Massage after withdrawal of the needle to insure spread (caution—use only 1 cc of efocaine) Although the procaine may wear off in an hour or two the relief of pain may persist for days or weeks when the nerve may be blocked again Efocaine effect will last for one or two weeks

Greater Occipital Nerve Block The greater occipital nerve is the medial *branch of the posterior primary division* of C 2 This is the largest posterior division of all the cervical nerves It divides into a small lateral branch and a very large medial branch It turns around the lower border of the inferior oblique crosses the suboccipital triangle and pierces the semispinalis capitis muscle and the trapezius and deep cervical *fascia just below the superior* nuchal line of the occipital bone Here it divides into branches which ramify in the scalp It is distributed to the skin of the scalp as far forward as the vertex and to the pinna supplying the skin of its upper part Occipital neuralgia is not a tic, not acute The onset is gradual and the condition waxes and wanes, but pain is present almost constantly Pain is over the occipital distribution to the vertex of the skull The scalp is tender The involvement is unilateral and is commoner in females Frequently they complain about pain in the ear being the most severe of the symptom-complex.

TECHNIC OF OCCIPITAL BLOCK

1 The patient lies prone (on face) with a pillow under the chest and flexes the head anteriorly

2 Palpate the spinous process of C 2

3 Two and a half cm (1 inch) lateral to the spinous process raise a wheal

4 With a needle go downward and inward to the articular process Pass the needle along the process for about 2.5 cm (1 inch)

5 Put in 4 cc. of novocain two per cent, and get cutaneous analgesia Then inject 1 to 2 cc of ninety five per cent alcohol or efocaine

Another technic is along the hair margin

1 Palpate the mastoid process and the occipital protruberance

2 Draw a line between these points and put a wheal at the lateral third of the line

3 Put in needle perpendicular to the skin and strike bone

4 Then slide down the bone 1 cm. and keep hitting the bone until paresthesia, upon contact with the nerve is elicited (shooting pains in the region)

5 Inject 5 cc. of novocain 1 cm inward Follow with ninety five per cent alcohol or efocaine (1 to 2 cc) without moving the needle

Nerve Blocks of the Neck The procedures for blocking the sympathetic fibers in the neck (stellate ganglion) will be considered under Sympathetic Blocks

Scalenus Anticus Syndrome: Spasm of the scalenus anticus muscle is not uncommon The muscle originates on the anterior tubercle of C 4 5 6 and 7 runs downward, and inserts in the scalene tubercle of the first rib Spasm of this muscle may cause compression of the fibers of the brachial plexus and vascular disturbances of the arm because of elevation of the first rib and semi-occlusion of the subclavian vessels

BLOCK PROCEDURE With the patient lying on the back and the head rotated to the opposite side, have patient lift the head while it is still rotated. The sternocleidomastoid muscle on the same side will become prominent and also the scalenus anticus muscle will appear as a small muscle bundle just lateral to the outer border of the sternomastoid near the clavicle With the head still elevated grasp the scalenus anticus muscle between the fingers of the left hand and with a syringe and attached hypodermic needle in the right hand inject 5 to 10 cc of one per cent procaine or 2 cc of efocaine

The scalenus anticus block is useful in the diagnosis of arm pain If the pain subsides after scalenus block, this is pathognomonic of spasm and thereby rules out the possibilities of cervical rib and ruptured cervical disk. A roentgenogram is helpful. If arm pain persists following proper and accurate scalenus block this absolutely rules out scalenus spasm as the cause of the pain and one should look elsewhere for the etiology

Phrenic Nerve Block The phrenic nerve arises chiefly from C 4 and also gets a few filaments from C 3 and 5 It passes medially and downward on the scalenus anticus muscle on its way to the diaphragm It is most easily blocked by the technic described above for finding the scalenus muscle The block is useful in the control of hiccough The right or left phrenic may be blocked first Following the block of one side, there is no necessity of blocking the opposite side if the hiccough subsides If the hiccough does not subside after blocking one side the procedure should be deferred for an hour or two and the other side blocked. Ten cc. of two per cent procaine or 2 cc of efocaine should be injected, using a short 23-gauge needle and moving it in several directions while injecting. Sarnoff has described a technic for phrenic block by means of an indwelling plastic catheter The method is involved and one may

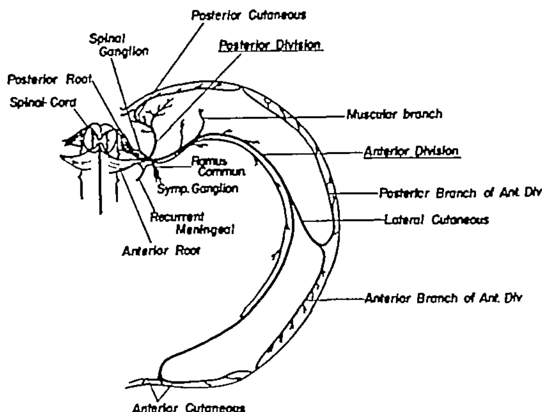


FIG 2. Cross section (schematic) of the spinal cord at T 4 level depicting the four primary divisions of the nerve fiber viz. anterior primary division, posterior primary division ramus communicans to the sympathetic chain and the recurrent or ramus meningeus to the meninges. In performing nerve blocks at a distance from the spine it is usually only the anterior primary division that is affected. Epidural block affects all divisions.

into the muscle substance for possible benefit after tender areas are determined.

Chest Pain Affections of the chest, externally and internally are frequently amenable to nerve block procedures A very common external affection is that which involves the intercostal nerves in a painful process This involvement may consist of diseased states or result from trauma. Local block therapy applied to the chest wall has been used in relieving pains with a cardiac basis The somatic component of the visceral nerve is affected [3] The chest muscles undergo a reflex spasm resulting from a viscero-motor reflex following cardiac disorders and cause the appearance of tender areas in the muscles of the chest wall (trigger areas) Rinzler likens this to "similar reflex spasm of the abdominal musculature in an acute surgical condition of the abdomen." Areas of referred pain on the chest are developed as the result of these spasms

TECHNIC The tender areas are carefully observed and marked. The injection of procaine into the areas should elicit the postulates of Steindler and Luck (see Low Back Conditions) The short, small gauge needle is introduced through the skin to the appropriate muscle (pectoralis major or minor or serratus anterior) and 5 cc. of 0.5 per cent procaine or 1.5 to 2 cc efocaine injected in several directions through the same wheal Incidentally the wheal should be a large one, sufficient to include the entire tender area. It is im-

portant that the reference zone of pain be also observed in determining the presence of cardiac pain as reflected to the chest wall (see Cardiac Pain) A typical intercostal space starts at the intervertebral foramen and ends at the *costochondral junction of the rib It is covered by*

1 Parietal pleura
2 Subcostal muscle
3 Costotransverse ligament (from the tip of the transverse process above and the neck of the rib below)

The intercostal nerves are accompanied by the intercostal arteries (from the aorta) and veins The intercostal muscle has two layers The nerve runs in between them to the anterior aspect of the rib There are four branches of the intercostal nerves as they leave the foramen (Fig 2)

(1) The posterior primary division
(2) The connecting branch to the sympathetic (white ramus communicans)
(3) The anterior primary division
(4) Ramus meningeus or recurrent branch (*which does not extend as far as the foramen*)

Sympathetic ganglia lie on the heads of the ribs (Fig 3) sympathetic chains lie on the bodies of the ribs (neck) They jump the gap between the vertebrae and the mass of fatty tissues Lower down in the chain the ganglia lie on the bodies of the vertebrae This is called paravertebral nerve blocking

Paravertebral Nerve Block A simplified technic is described by Shaw [4] The danger of pneumothorax however is everpresent but minimal by this method With the patient in the prone position or sitting up the spinous processes at the desired levels are accurately localized, palpated and marked, and a point 1 cm lateral to the upper border of the spinous processes is also marked at each level. At this point, the lamina of the vertebra is located about the level of the intravertebral foramen. Wheals are raised at these points with procaine

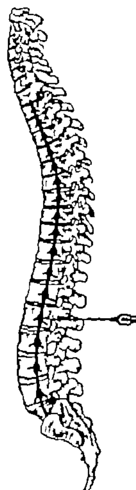


FIG. 3 Lateral view of the vertebral column with the paravertebral sympathetic chain in place. The location of the chain varies in different individuals but usually lies posterior in the cervical region and then gradually runs anterior until in the lumbar region it is anterolateral on the body of the vertebrae. The needle is at the level of L 2 and indicates the method of performing a lumbar sympathetic block with the patient sitting up. (See text—Lumbar Sympathetic Block.)

A 7.5 cm (3 inches) 22 gauge needle is inserted perpendicularly until contact with the lamina of the vertebra is made (Fig 4) The needle is partially withdrawn and redirected more laterally until it is felt just slipping off the edge of the lamina at which time it is advanced 1 cm further If bone is struck (when attempting to slip off the edge) the needle is redirected more laterally to an angle of forty five degrees or more

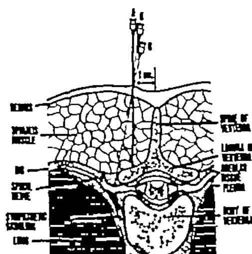


FIG. 4 Method of performing medial paravertebral block. Cross section through a thoracic vertebra. The needle is inserted at A to contact the lamina. B needle moved laterally to slide along the lamina. C. needle off lamina and advanced 1 cm. to contact nerve. (From W M Shaw "Medial Approach for Paravertebral Somatic Nerve Block" J.A.M.A.)

either upward or downward, until bone is no longer contacted, after which it is inserted 1 cm. further as described Careful aspiration is done to make sure the needle is not in a blood vessel, the pleura, or the subarachnoid space Five cc of two per cent procaine (for short anesthesia) or 2 cc of efocaine (for prolonged anesthesia) are injected at each level. Ninety five per cent alcohol has been employed, but the danger of alcohol neuritis is everpresent and the resultant pain is worse than the original condition

Herpes Zoster (Shingles) This painful affection is usually of the chest wall and of the abdominal wall and may also involve the extremities which has its origin in inflammation of the posterior root (spinal) ganglion In frequently it occurs on the face over the distribution of the trigeminal nerve It occasionally responds to paravertebral nerve block or gasserian ganglion block. Anatomically the spinal ganglion is medial to the block and should not produce relief from pain, theoretically However the cutting-off of afferent impulses distal to the ganglion stops the bombardment of impulses and occasionally relieves the distressing pain This may be accompanied by repeated procaine paravertebral blocks, using 5 cc. of two per cent procaine, or 2 cc of efocaine, at each level (Fig. 4) Epidural block with fifty to ninety five per cent alcohol or efocaine has been found very useful when the condition is located in the thoracic region (see Epidural Block)

The Pain of Fractured Ribs. Fractured ribs often produce extremely painful results due to trauma to the inter costal nerves by the fragments in their continual movement caused by respiration These are very frequently relieved by paravertebral blocks (Fig. 4) Depending upon the site of fracture paravertebral or intercostal nerve blocks may be performed It is the usual practice to use procaine followed by ninety five per cent alcohol for this purpose Efocaine 2 cc may be employed in place of alcohol to avoid the possibility of alcohol neuritis The fragments may be directly injected with efocaine Epidural block with efocaine or alcohol has been useful (see Epidural Block)

Intercostal Nerve Block Intercostal nerve block may be employed particularly for surgery on the poor risk patient, or for the prevention of abdominal pain following surgery If the procedure is to be employed for surgical operation the dermatomes concerned with the areas to be operated on must be carefully considered. If the operation is to be on the upper abdomen (stomach gallbladder pancreas etc.), the intercostal nerves, T 4 to T 8 must be blocked.

PROCEDURE The nerves are blocked usually at the posterior axillary line and must be done bilaterally for surgical operations For postoperative pain relief only one side is blocked The appropriate ribs are located and, using a 7.5 cm (3 inches) 20 gauge needle, the procedure is carried out as follows Each rib is "straddled" by the second and fourth fingers so as accurately to orient it in the operator's mind. The third or middle finger contacts the center of the rib the needle is advanced near the lower border of the rib (guided by the middle finger) through the anesthetic wheal until the rib is contacted. The skin over the rib (and the needle) is now moved downward to the inferior border of the rib The direction of the needle is then changed upwards and inwards at an angle of forty five degrees in each plane (Fig 5) until the point of the needle again contacts bone in the subcostal groove Careful aspiration is now made to avoid intravascular injection and 5 cc of two per cent procaine 2 cc. of efocaine or 2 cc of two per cent xylocaine are deposited This procedure is repeated at all the predetermined ribs and as stated, must be done bilaterally for abdominal surgical operations. It may be preceded by posterior celiac ganglion block with the patient in the prone position (Fig 6) or it may be followed by anterior celiac plexus block after the abdominal cavity has been opened by locating the first lumbar vertebra and injecting, retroperitoneally 20 cc. of two per cent procaine or one per cent xylocaine The necessity for direct retroperitoneal celiac ganglion block may be obviated by merely instilling 30 cc of 0 5 per cent xylocaine through the abdominal opening (with no pads *in situ*) and waiting ten minutes for it to act. Xylocaine has an excellent local anesthetic effect on serous membranes.

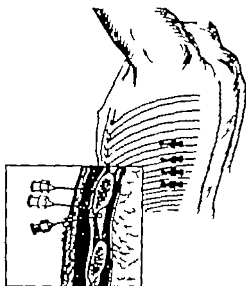


FIG. 5 Intercostal block of thoracic nerves at the posterior axillary line. Insert—The needle first contacts the rib, then is moved caudad to slip off the bone. The lower needle depicts the proper placement to reach the nerve in the subcostal groove.

For postoperative wound analgesia these procedures for intercostal nerve block may be done at the appropriate levels on one side using 2 cc of efocaine or 1 cc. of ninety five per cent alcohol at each intercostal space (Fig. 5) This renders the wound area insensitive for a period of days or weeks and by the absence of pain respiratory inhibition

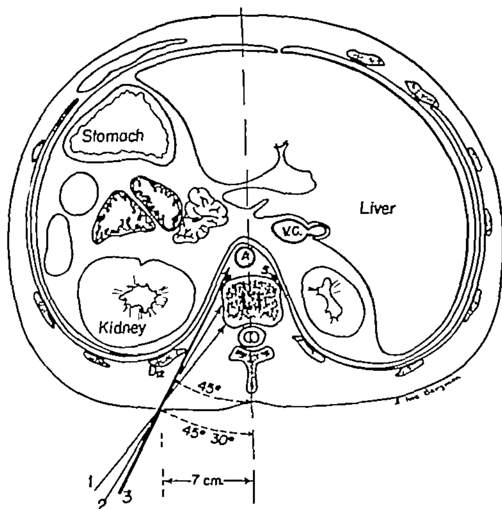


FIG. 6. Diagram of method of performing lumbar sympathetic block by using a point 7 cm. lateral to the spinous process. At (1) the needle is inserted at an angle of twenty-five to thirty degrees with the midplane of the body The point now impinges on the posterior portion of the body of the vertebra. The angle is increased (2) and the needle steadily advanced until contact with the body is no longer obtained (3) The needle is now withdrawn 1 cm. which puts the point in contact with the lumbar sympathetic chain at the anterolateral portion of the body of the vertebra. For celiac ganglion block, the needle is advanced 1 cm. further after losing contact with bone (3) *A—aorta V C—vena cava, S—sympathetic chain.*

due to pain is overcome, thus preventing the occurrence of atelectasis due to painful reflex respiratory depression.

Segmental Neuralgia This is defined by Judovich and Bates[8] as an area of spontaneous pain with one or more tender skin sensory segments (dermatomes) It may be caused by any disease process absorption of toxins or any mechanical irritation of the nerve The causes of pain are many ranging from upper respiratory conditions to malignancy diabetes or blood dyscrasias and most commonly are found over the distributions of the twelfth dorsal and first lumbar nerve The diagnosis depends upon the pattern of tenderness which is associated with the pain, rather than concentrating upon the area of which the patient complains,

Spinous process
Epidural space (Posterior)
Spinal artery to nerve roots and Epidural space
Point at which nerve is affected by Epidural Block
Epidural space (Anterior)
Dura mater
Dural projection to intervertebral space
Subarachnoid space
Body of vertebra

FIG 7 Cross section of vertebra in thoracic region. Epidural anesthetic injections made here affect the nerve fiber after the dural projection ceases, *i.e.* at the intervertebral space. All four branches of the nerve fiber are affected here. The space is filled with fat and loose connective tissue and a dense plexus of fine blood vessels (from Ansbro *et al* N Y S. J Med. with permission)

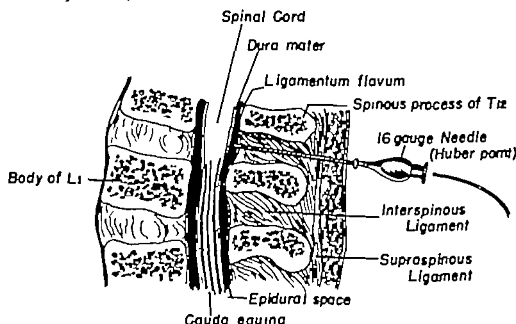


FIG. 8 Longitudinal section of the bony spine between D 12 and L 2 indicating the structures a needle traverses in reaching the epidural space. (From Ansbro *et al* N Y S. J Med. with permission.)

thereby localizing the origin of pain to definite areas and levels It may also be due to faulty posture As stated it is frequently confined to dermatomes covered by D 12 and L 1 Paravertebral blocking of these somatic segments with 5 cc. of two per cent procaine or 2 cc. of efocaine may result in improvement. It is also frequently necessary to make postural corrections or to supply mechanical supports

Epidural Block This procedure is probably beyond the scope of the surgeon's work However it is mentioned in detail because of its great value in relief of pain Only those skilled in the procedure should attempt it It is useful for the injection of alcohol for the relief of pain particularly in cancer The procedure of epidural block is done by locating the spinal nerves involved in the pain syndrome and placing a Touhy catheter in the epidural space (Fig. 7) at the appropriate segment (Fig. 8) After a small dose of procaine (100 mg.) is injected to

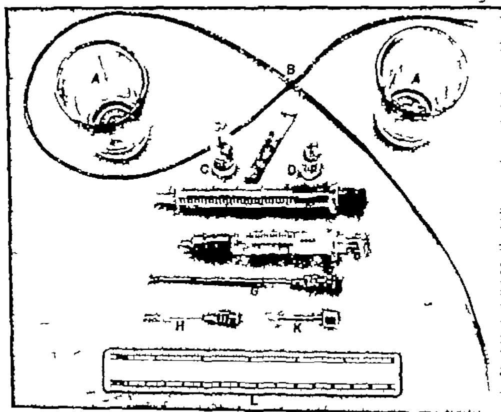


Fig. 9 Equipment for performing intraspinal segmental alcohol block.
A—Glasses for two per cent procaine and alcohol.
B—Touhy catheter with stylet in place.
C—Absolute alcohol.
D—Procaine.
E—Tuberculin syringe for injecting alcohol in minims.
F—2 cc. syringe for procaine wheal in skin.
G—16 gauge Huber point needle through which catheter is inserted.
H—23 gauge needle used with tuberculin syringe for injection through catheter
K—Skin awl for puncturing skin and supraspinous ligament to aid in insertion of 16 gauge needle.
L—Ruler for measuring distances on back and on roentgenogram. (From Ambro Intraspinal Segmental Alcohol Block, Courtesy of Am. Jour Surg.)

insure that the catheter is not in the subarachnoid space, twenty to ninety five per cent alcohol may be injected, with the patient lying on the affected side in quantities varying from 2 to 5 cc. The latter amount is usually sufficient to affect three to four segments If the catheter is skillfully placed to one side or the other one may obtain a unilateral block. The placement of the catheter may be confirmed by x rays The procedure may be used for pains in any locality—cervical, thoracic, lumbar or sacral The sacral pain may be attacked by the caudal route but must be used with extreme caution in this locality because of the presence of the nervi erigentes that supply autonomic impulses to the sphincters of the bladder and the anus However in other regions, particularly thoracic it has proven very satisfactory (in the writer's experience) The catheter may be left in place and the injection through the catheter repeated in two or three days if the initial injection has not satisfactorily blocked the pain It is useful also for the relief of pain due to herpes zoster We consider the epidural injection of alcohol a method superior to the paravertebral use of alcohol for nerve blocking, not only because of the ease with which the procedure is accomplished, but also on account of the accurate localization of the anesthetic solutions We now employ ninety five per cent alcohol as the optimum concentration (3 to 4 cc at each injection) and have had no incidence of alcohol neuritis.

Subarachnoid Alcohol Injections These are usually employed for the relief of pains due to cancer In the writer's opinion, alcohol injections into the subarachnoid space are never justified for any other purpose

The method of injection formerly employed was by means of a needle at the proper interspace (but usually in



FIG. 10 Depicting needle inserted between L 4 and 5 vertebrae and the catheter ascending to the predetermined height. (From Ambro Intraspinal Segmental Alcohol Block Courtesy of Am. Jour Surg.)



FIG. 11 Roentgenogram of catheter in subarachnoid space A—End of catheter at level of C 5 B—Catheter inserted at lumbar interspace (From Ambro, Intraspinal Segmental Alcohol Block Courtesy Am. Jour Surg.)

the lumbar region) and with the patient lying on the side opposite to the painful one and in acute lateral flexion, a 22 gauge, 7.5 cm (3 inches) spinal needle was inserted and ninety five per cent alcohol ranging in volume from 0.5 to 1.5 cc depending upon the extent of block desired, was injected slowly The specific gravity of alcohol being lower than that of spinal fluid caused the alcohol to rise to the surface of the spinal fluid and on its floating upon the surface to cause neurolysis of the nerve roots and particularly the posterior root ganglia of the uppermost side This procedure was unsatisfactory because it often caused sphincter paralysis and occasionally paralysis of the somatic motor nerves. On that account, the writer developed the procedure of intraspinal segmental alcohol block [6] By means of this procedure a Touhy catheter (Fig 9) is placed through a 16 gauge Huber point needle (Fig. 10) and advanced to the nerves affected in their peripheral distribution by the painful process Under x-ray guidance (Figs 11 and 12) the intervals between emergence of each spinal nerve through the intervertebral foramens is measured on the film and the catheter is withdrawn to a distance corresponding to each measurement. At each interspace, absolute alcohol is injected through the catheter which has al-

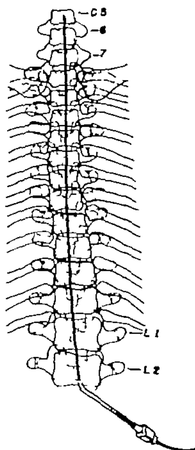


Fig. 12. Diagram of catheter placed through needle at L 2 and 3 interspace and extending to the C 5 level. (From Ansbro, Intraspinal Segmental Alcohol Block, Courtesy Am. Jour Surg.)

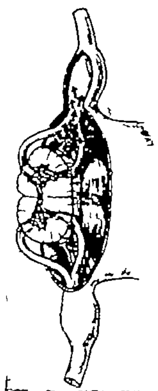


Fig. 13 Diagrammatic representation of catheter ideally placed in subarachnoid space at appropriate height. Arrows indicate the alcohol rising to the top of the fluid level and affecting the posterior root ganglion. (From Ansbro Intraspinal Segmental Alcohol Block Courtesy Am. Jour Surg.)

ready been filled by the solution. With the patient lying on the side opposite the pain one or two minims of absolute alcohol are deposited at each interspace This amount is sufficient to effect a neurolysis of each posterior sensory ganglion (Fig 13) The method has produced some good results particularly in cervical and upper thoracic lesions. However we now consider epidural alcohol block superior to this method

LOWER EXTREMITY BLOCKS

1 For analgesia
2 For diagnosis
3 For therapeusis

The lower extremity extends from the lumbosacral region to the tip of the toe Affections of the lower extremity include disturbances of the back, for the trunk is the site of origin of the nerve supply of the lower extremity The nerves extend from D 12 to S 2

Hip joint—nerve supply is especially from L 4
Knee joint—from L 5
Ankle joint—from S 1

Painful conditions of the lower extremity require careful examination to determine the origin and cause of the pain The etiology may range from simple neuritis to ruptured intervertebral disk in the lumbar region It is seldom that neuritis *per se* is the single cause of lower extremity pain. So-called sciatica is better considered primarily as a symptom rather than as a clinical entity in itself Hence merely blocking the sciatic nerve for "sciatica" does not have a rational basis

Procedure Any one of the nerves of the lower extremity may be blocked individually or collectively by the para vertebral route This method however is seldom employed practically for this purpose but is frequently used for diagnostic and surgical purposes For diagnosis (*e.g* causalgia or painful phantom limb) selected nerves may be blocked with procaine to determine which one or more is mediating the painful impulses If not more than one, this nerve may be blocked with alcohol to produce lasting relief Usually the blocking of one nerve of the lumbosacral plexus will not result in any motor disturbance

Sciatic Nerve (Sciatica) The sciatic nerve originates from the anterior primary division of L 4 and 5 and S 1 2 and 3 It passes on the anterior surface of the sacrum through the great sacrosciatic notch. It courses downward between the piriformis and superior gemellus muscles It runs downward to the posterior aspect of the thigh between the vastus posterior and the adductor magnus and hamstring muscles to the apex of the popliteal space where it divides into the tibial and common peroneal nerves

Sciatic block may be performed by four methods (Fig. 14)

With the patient in the Sim s position, the upper border of the greater trochanter of the femur is located From this point, three lines radiate *One* line to the posteriosuperior spine of the ilium of the same side Bisect this line and measure downward 3 cm on the bisector A long needle is passed through a wheal at this point and contacts the sciatic nerve at varying depths according to the weight of the patient. Contact with the nerve is signified by radiating parasthesias running through the nerve and its branches Five cc. of two per cent procaine are injected without moving the needle *Warning* Do not inject alcohol in the sciatic nerve because it may cause motor disturbances

The *second* line from the trochanter is advanced to the sacrococcygeal junction

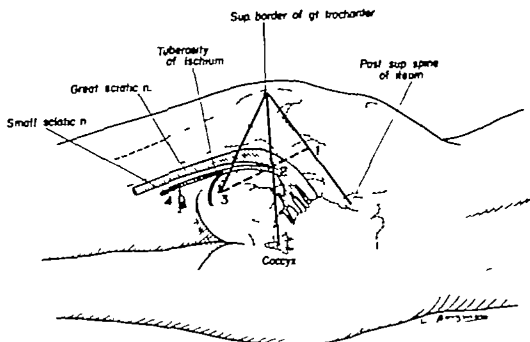


FIG. 14. Sciatic nerve block. Diagrammatic representation of four methods of reaching the nerve. The superior border of the greater trochanter of the femur is the starting point for three of the lines. (See text for descriptions of methods.)

At the midpoint of this line or a finger breadth medial to it, a wheal is raised and the needle injected perpendicularly to contact the nerve Parasthesias must be elicited before injecting the solution. The nerve at this point overlies the spine of the ischium

The *third line extends to the ischial* tuberosity and is divided into three equal parts At the junction of the medial third and the lateral two-thirds of the line, a needle is passed and contact with the nerve is sought. Also the tuberosity of the ischium may be palpated and 2 or 3 cm. lateral to its external surface a wheal may be raised and the needle passed through this point perpendicularly

A *fourth* method of locating the sciatic nerve further down the leg is at a point located about 5 cm below the gluteal fold and 1 to 2 cm. medial to the center of the femur A wheal is raised here and a needle inserted perpendicularly After the bone is contacted, the needle is moved around in search of parasthesias When the nerve is located, the anesthetic solution is injected without moving the needle.

The *piriformis muscle* when it becomes spastic, may cause sciatic pain by *compressing the nerve between its fibers* and for this reason procaine solution (two per cent) may be deposited in the substance of the muscle This block may be accomplished by using method one *i.e* the line running between the upper border of the greater trochanter and the posteriosuperior iliac spine The midpoint of this line is measured and a line drawn at right angles to it. At 1 cm. down this line a wheal is raised and the needle advanced to the piriformis muscle Inject 10 cc. of two per cent procaine one per cent xylocaine or 2 cc. efocaine in several directions

It has been suggested by Cheeley[7] that a continuous blockade of the sci-

atic nerve could be effected by passing a large bore needle (17 gauge) through the skin and muscles of the back according to method number 1 (above) Through this large needle a Touhy catheter is passed as far as the point of the needle and slightly beyond it and, after removing the needle the catheter is strapped to the skin surface and fractional injections of anesthetic solutions (procaine xylocaine or mety caine) are made The writer has had no experience with this method and cannot comment on it

Sciatic Block for Fracture For the emergency reduction of a fracture of the lower extremity but particularly for fracture of the tibia and fibula or the os calcis a block of the sciatic nerve will give pain relief and relaxation The block may be performed by any of the methods outlined above

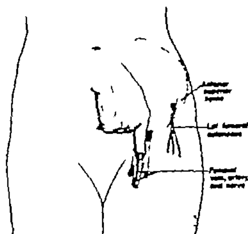


FIG. 15 Block of femoral and lateral femoral cutaneous nerves. The femoral and lateral cutaneous nerves are indicated. Palpating the femoral artery just below the inguinal ligament, the nerve is found lying just lateral (1 cm.) to it Injection is made just under the fascia without seeking parasthesias. The femoral vein is just medial to the artery The lateral cutaneous nerve is blocked for meralgia parasthetica 1 cm medial and 1 cm. caudad from the anterior superior iliac spine The

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**Local Injection for Frac
Sprains of the Structure
Lower Extremities.** May be
by (a) Localization of the f
sprain site (b) Injection of
solution usually one per cent
into this site (Fig 16) If t
invades the hematoma about
and procaine is combined w
ronidase to insure adequate sp
the solution there is a great r
pain and spasm permitting th
lation of the fragments One
procaine without hyaluronidase
be used as well as 0 5 to 1

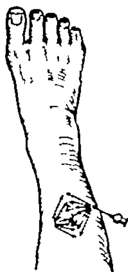


FIG. 16. Local injection of fracture site with efocaine indicating the fine lines of anesthesia which are made by injecting in a fan-wise manner about the fragments. Do not pool the solution. Procaine one per cent may be deposited into the hematoma between the fragments.

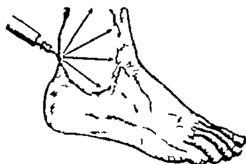


FIG. 17 Local injection for ankle sprain with efocaine. A procaine wheal is made and a 22 gauge, 7.5 cm. (3-inch) needle is inserted through the wheal to the deeper structures. Injection is begun as the needle is withdrawn and is repeated in several directions. Each tender spot must be injected in the same manner With procaine one or two per cent, the same procedure may be used more liberally Efocaine action may last seven to twelve days. The action of procaine is only for an hour or two but the relief of pain persists long after the anesthesia *per se* has worn off. After the injections, the patient must be encouraged to walk about and use the foot.

substance should be 25 to 30 cc In *ankle sprains* quick and sometimes last ing relief of pain and disability may be obtained by local infiltration into the tender spots about the sprained area (Fig. 17) It is of great importance to locate *all* the tender spots and to inject them separately with one per cent procaine. If all the tender areas are injected, the patient frequently feels immediate relief and is able to walk about on the previously disabled part. In a surprising number of cases, this relief persists for hours or days The injections may be repeated as often as necessary after improvement is noted. This treatment should be instituted only after careful examination and x ray evidence shows absence of fracture or osseous disease Efocaine is demonstrating its worth in the local treatment of fractures or sprains The tender spots are located, or the fracture site determined, and skin wheals made of one per cent procaine A 22 gauge needle is introduced through each wheal successively to the fracture site or to the depth of the sprain area and efocaine injected as the needle is withdrawn through the tissues The needle is reintroduced through the same wheal in another direction and efocaine injection made in the same manner thereby creating many fine anesthetic lines through the area. Efocaine should never be pooled and only 1 cc used for each line with a maximum of 10 cc., widely distrubted, in any one fracture site or sprain area Usually using efocaine, it is not necessary to inject more than once, which is a distinct advantage over procaine Following the injections, the patient must be encouraged to walk about and use the foot.

Meralgia Paraesthetica (Thigh Pain) Irritative neuralgia affects the lateral cutaneous nerve (derived from L 2 and 3) This is a disease marked by paraesthesias on the outer surface of the

thigh. The paraesthesias consist of burning tingling stabbing pains of considerable severity or possibly only a feeling of numbness The sensory disturbance varies from slight hyperesthesia to total anesthesia It is occasionally referred to as "Bernhardt's Disturbance of Sensation" The hyperesthetic area on the outer surface of the thigh may be identified by pin-scratch along the lateral surface of the thigh. As the needle progresses from a nonaffected area, it will suddenly run into an area in which the patient complains of more or less severely painful sensations (hyperesthesia) The condition has occasionally been associated with sciatica and possibly results from the use of strapping with adhesive tape or sacroiliac belt for low back pain or sciatic pain. Thus it may be caused by pressure or tension on the lateral cutaneous nerve. It is usually unilateral

BLOCK PROCEDURE The nerve is blocked as it passes under Poupart's ligament just medial to the anterior iliac spine (Fig 15)

(1) Locate the anteriosuperior iliac spine Palpate the origin of the sartorius muscle and in the angle between the muscle and the lateral extremity of Poupart's ligament the nerve is located.

(2) Put a wheal 2.5 cm medial and 2 cm caudad to the anteriosuperior iliac spine

(3) Using a 7.5 cm (3 inches) 22 gauge needle advance it toward the anteriosuperior spine under Poupart's ligament. If as the needle advances the nerve is not contacted before it touches bone, then change the direction of the needle in a fan-wise manner Paraesthesias must be obtained.

(4) Inject 10 cc of two per cent procaine solution without moving the needle If anesthesia results a prolonged effect may be obtained by a second injection of 3 cc. efocaine or 2 cc. of ninety five per cent alcohol When efocaine is employed the needle should be moved in several directions while injecting to avoid pooling the solution

Caudal Block. The blocking of the fibers of the sacral plexus has assumed increasing importance, not only for surgery or for the relief of pain from le-

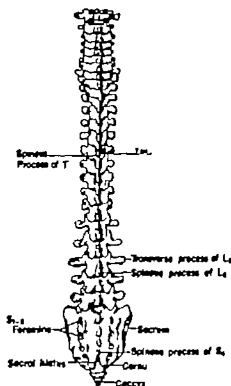


FIG. 18 Posterior view of the vertebral column The numbers at T 7 indicate the various distances from the tip of the spinous process that paravertebral block is performed. At 1.5 cm. distance the needle strikes the lamina and is moved laterally (Shaw) At 4 cm. the transverse process is contacted and the direction of the needle is changed to an angle of twenty-five degrees downwards and inwards towards the intervertebral space At 7 cm. a long needle is directed at thirty degree angle to the axis of the spine avoiding the transverse processes and contacting the body of the vertebra (In the lumbar region) (See Fig. 6) The boundaries of the sacral hiatus form a triangle The apex is the spinous process of S 4 and the base is formed by a line between the two cornua.

sions of the anus and rectum but also for sympathetic nerve paralysis of the pelvis and lower extremities The latter is particularly useful in peripheral vascular affections. The caudal hiatus is usually easily palpated at the end of the vertebral column as a triangular space. Occasionally it is difficult or impossible to palpate and if so the procedure should be abandoned. The boundaries of the caudal hiatus (Fig 18) that form the triangle are the two cornua of the sacrum and the spinous processes of S 4 A 7.5 cm (3 inches) 20 gauge needle is inserted through a wheal made in the center of this triangle perpendicular to the skin and after contact with bone (posterior surface of the anterior plate of the sacrum) the needle is depressed through forty degrees caudad and inserted through the caudal hiatus a distance of 2 to 3 cm., keeping in mind that the dura extends downward to the level of S 2 (Fig. 19) After careful aspiration to rule out subarachnoid puncture or entrance into a blood vessel, 5 cc. of two per cent procaine (100 mg) are injected and a waiting period of five to ten minutes should elapse before subsequent injections to insure that no inadvertent subarachnoid injection (spinal anesthesia) has taken place Following this an additional 25 cc may be injected, moving the needle downward 1 cm. between each 10 cc. injected The last few cc should be injected at the caudal hiatus just under the skin and sacrococcygeal ligament. Twenty cc. of one per cent xylocaine may be used in place of procaine Do not use efocaine in the caudal canal. This will anesthetize the saddle area and also when using sufficient procaine or xylocaine (20 to 30 cc.) the lumbosacral plexus is affected producing a sympathetic block of the lower extrem-

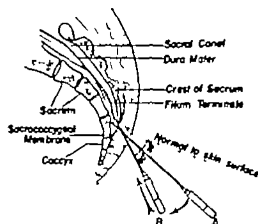


FIG. 19 Saggital section through sacrum indicating method of performing caudal block. The dura mater terminates at the level of the second sacral vertebra although it may extend lower Perforation of the dura and injection of 30 cc., two per cent procaine (600 mg.) constitutes the danger in caudal block massive spinal anesthesia ensues. The needle point should always be kept below S 2 level. The needle is inserted at right angles to the surface of the skin and depressed through an arc of forty degrees to enter the sacral canal.

ity which has been found useful in peripheral vascular conditions (frostbite, thromboangiitis obliterans etc) Occasionally the use of a continuous caudal block, as described by Southworth and Hingson, may be employed for this purpose We have found continuous lumbar epidural block superior to the latter procedure when we are seeking prolonged vasodilatation of the lower extremities In painful conditions of the anorectal region, as in acute thrombotic hemorrhoids, anal fissures, or posthemorrhoidectomy pain, the employment of a continuous caudal block with procaine through an indwelling needle or polyethylene catheter frequently gives continuous relief in severely painful areas

LOCAL INJECTIONS FOR ANORECTAL CONDITIONS

The surgeon will find these injections

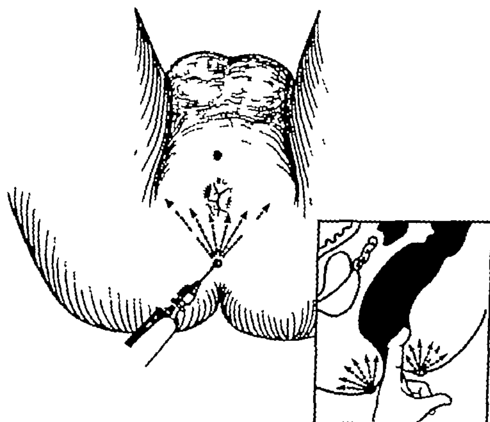


FIG. 20. Local injections for anorectal conditions. Wheals are raised above and below the anus with procaine. With a 22 gauge 7.5 cm. (3-inch) needle connected to a syringe containing efocaine, fine lines of anesthesia are made in the deep structures. The needle is advanced to its full depth and the injection begun as the needle is withdrawn. Injections are repeated in a fan-wise manner. Insert finger in rectum to prevent perforation by the needle

particularly useful in his office practice of proctology or in the home for the immediate relief of severe pain due to acute thrombotic hemorrhoids, anal fissures, etc As described before a caudal anesthetic may be utilized, but occasionally this is impracticable Local injections about the anus are more easily performed although more painful to the patient. The technic of infiltration is simple There is no prolonged waiting time and it may be performed in the lithotomy or the lateral Sim's position At the beginning the first injection which may be placed at any point about the circumference of the anus, a wheal is raised with a very fine needle about one fingerbreadth distant from the anus (Fig 20) Through this wheal the region is circumscribed by an area of infiltration of the anesthetic solution. Upon completion of the subcutaneous infiltration, the left index finger is inserted into the anus and using a 22 gauge 7.5 cm (3 inch) needle with syringe attached, the needle is passed into the deep anal sphincter The finger in the rectum should insure against perforation of the lumen of the bowel and it enables the needle to be guided correctly as to its depth. The usual distance is 3 to 4 cm Four areas are thus injected, equidistant apart, and injection made of the anesthetic solution

at each location the needle being slowly withdrawn after each injection This produces a relaxation of the sphincter and usually stops the pain due to spastic anal sphincter Solutions of one to two per cent procaine or one per cent xylocaine may be used if the procedure is to be followed by operation If prolonged relief is the primary requisite efocaine is useful. If efocaine is to be employed, the quantity should be much less than procaine and no more than 1 cc should be deposited at any one spot. In other words "pooling" of the solution should be avoided. The injections of efocaine should be deep (subcutaneous or intramuscular) and made in a fan-wise manner creating a series of anesthetic lines This is best effected by beginning the injection with the needle deep in the tissues and continuing the injection as the needle is withdrawn. It is then reinserted at another angle and the injection repeated. This will insure the nonproduction of sloughs or sterile perianal abscesses which are prone to occur following oil-containing anesthetics Efocaine should never be used for the skin wheal, always employ procaine hydrochloride for this purpose A patient suffering from an acute thrombotic hemorrhoid may obtain immediate relief by this procedure and the thrombosed blood vessel may be emptied of its contents by excision. Hemostasis must be insured by pressure The anesthetic solution (efocaine) should render the area insensible to the presence of packing

Pruritus ani is amenable to local injection therapy Alcohol ninety five per cent has been used in the past by injecting a few minims in many discrete areas about the anus This, however may result in slough. Efocaine is a much safer agent and gives good results when the

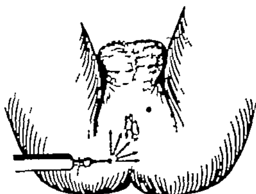


FIG. 21 Local injection of efocaine for pruritus ani Four wheals are made equidistant about the anus and the solution injected into the deep structures in a fanwise manner avoid pooling of the solution.

technic is carefully performed (Fig 21) Wheals of procaine hydrochloride one per cent are placed at four quadrants situated about 5 cm from the anal orifice Through each wheal successively a 22 gauge 7.5 cm (3 inch) needle is inserted with syringe containing efocaine attached The needle point is inserted at an angle of forty five degrees to the anus to the deeper perianal structures (a finger in the rectum will guard against puncturing the wall of the canal) The efocaine solution is injected as the *needle is withdrawn, thereby creating a* fine line of anesthesia The needle is reinserted in another direction and injection similarly done Five lines may be made at each quadrant, avoiding pooling of the solution

Pudenal Nerve Block The innervation of the anal region is also supplied by the pudendal nerve which is derived from the anterior rami of S 2 3 and 4 It becomes accessible at the ischial tuberosity where the inferior hemorrhoidal nerve, which supplies the external anal sphincter and perianal skin may be blocked. Bilateral intradermal wheals are made midway between and 1 cm below the ischial tuberosities and the

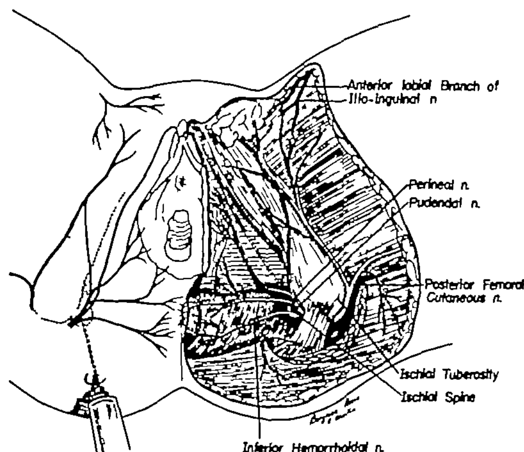


FIG. 22. Pudendal nerve block. A wheal is raised midway between and 1 cm. below the anus and the ischial tuberosity A 7.5 cm. (3 inches) 22 gauge needle is directed to contact first the spine of the ischium for block of the pudendal nerve and its branches and then the tuberosity for block of the posterior femoral cutaneous nerve and its branches. Radial injections are then made in the direction of the anus and vagina.

rectum. A 7.5 (3 inch) 22 gauge needle is passed to the ischial spine The needle is guided by a finger in the previously anesthetized rectum (*e.g* xylocaine ointment five per cent) or in the case of a female by two fingers in the vagina (Fig. 22) On contact with the ischial spine 15 cc of 0.5 per cent procaine are injected. This procedure blocks the internal pudendal nerve on its way to Alcock's canal as it passes dorsal to the ischial spine The other branches of the pudendal (perineal nerve) must be blocked The deep branch of this nerve supplies the levator ani muscles and the superficial and deep perineal muscles as well as the ischiocavernosus and bulbocavernosus muscles and the sphincter of the membranous urethra. A superficial branch supplies the labium majus

VULVA AND VAGINA

Analgesia of the Vaginal Outlet During Parturition Following the above procedure for blocking at the ischial spine the needle is then withdrawn to the subcutaneous tissue and redirected laterally to the ischial tuberosity (Fig 22) On contact with bone 15 cc. are injected to block the perineal branches of the posterior femoral cutaneous nerve The injection at the tu

berosity is followed by infiltration in a radial fashion towards the vagina and anus with 15 cc. of solution In the latter procedure it is important to use dilute solutions so that a large quantity may be utilized. (0 5 per cent procaine or 0.5 per cent xylocaine or 0 15 per cent pontocaine with or without hyaluronidase)

Prolonged Relief of Postepisiotomy Pain Cappe and Pallin employed efocaine in a series of cases for the relief of pain and discomfort following episiotomy for vaginal delivery and reported satisfactory results [8] *Technic.* In those patients not under anesthesia procaine wheals are placed about 1 cm. at each side of the episiotomy incision and a long 20 gauge needle is inserted into the subcutaneous tissue 6 to 12 mm (¼ to ½ inch) parallel to the incision and extended up to the mucocutaneous junction The syringe containing efocaine is attached and the injection begun as the needle is withdrawn forming a fine anesthetic line The same procedure is done on the opposite side. From 6 to 12 cc of efocaine produced numbness of the parts sufficient to abolish pain for three to five days

Pruritus Vulvae: Alcohol ninety five per cent has had a wide use in this distressing condition, but complications in the way of sloughs, increased pain, etc. caused all but a few to abandon the procedure. The alcohol is placed in minim doses in discrete spots about the pruritic area with a fine needle. Sometimes as many as twenty five injections are made. Efocaine has proved much safer *Technic.* Procaine wheals are placed at the base of the vagina about 2 cm. from the mucocutaneous junction on each side (Fig. 21) A long 20 gauge needle is inserted through the wheal to the subcutaneous tissues and directed parallel to the skin of the labium majus to the base of the mons veneris A syringe containing efocaine is attached to the needle and the injection begun as the needle is slowly withdrawn through the tissues thus creating a fine line of anesthesia. The needle is reinserted through the same wheal in several tangential directions and similar lines created. Both sides are injected with about 5 cc on each side. The solution should not be pooled in any one place Strict asepsis is essential.

BLOCKS OF THE UPPER EXTREMITY

The branchial plexus is the most important single point of injection for anesthesia of the arm and hand. It is the most easily performed block for the upper extremity and is therefore chosen when it is desirous to perform surgery or manipulation at any point distal to it. Blocks of the brachial plexus may be performed for surgical diagnostic or therapeutic purposes The surgical emergency requiring brachial plexus block is a patient whose condition does not warrant general anesthesia because of his pathological state (shock, etc.) and other hazards possibility of fire, etc., and also when local infiltration is not feasible as in infected areas In addition, it is indicated when the patient has a full stomach and is thus liable to vomit during or following general anesthesia It is particularly useful in office or home practice where the reduction of a fracture is contemplated If sympathetic block of the arm is desired, the plexus may be blocked when the stellate ganglion is not accessible or the technic of stellate block is not familiar

Anatomy of the Brachial Plexus It is derived from the anterior primary divisions of C 5 6 7 and 8 and T 1

which are the roots of the plexus These nerve *roots* join together to form three *trunks* which, in turn, divide into six *divisions* These latter divisions form unions from which the three cords of the plexus are formed. The cords in turn give off the five main nerves of the plexus. Thus the brachial plexus may be said to begin with five nerves and end with five nerves with subdivisions of three between them The plexus passes dorsal to the vertebral artery between the anterior and middle scalene muscles and into the posterior triangle of the neck It crosses downward and passes across the first rib on its way to the axilla. The relationship of the plexus to the subclavian artery which also crosses the first rib is extremely important to remember in performing the

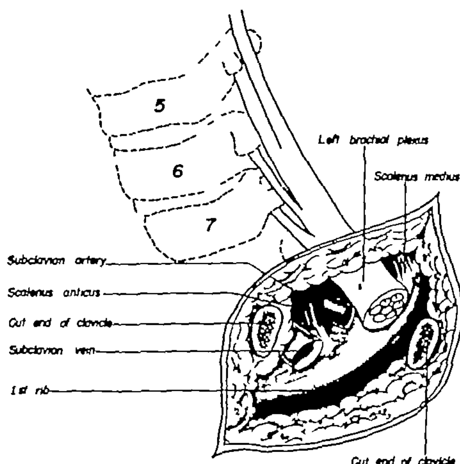


Fig. 23 A to E. Continuous brachial plexus block From a scientific exhibit by the author at the convention of the American Medical Association, Atlantic City June, 1949

(Redrawn from Macintosh and Mushin, Brachial Plexus Block, Blackwell Scientific Publications, Oxford. All figures from Ansbro, Method of Continuous Brachial Plexus Block, Courtesy of American Journal of Surgery)

A Anatomical position of the brachial plexus which lies lateral to the subclavian artery and between the insertions of the scalenus medius and anticus muscles. The subclavian vein is separated from the artery by the scalenus anticus muscle and lies under the surface of the clavicle and is not liable to puncture by needle.

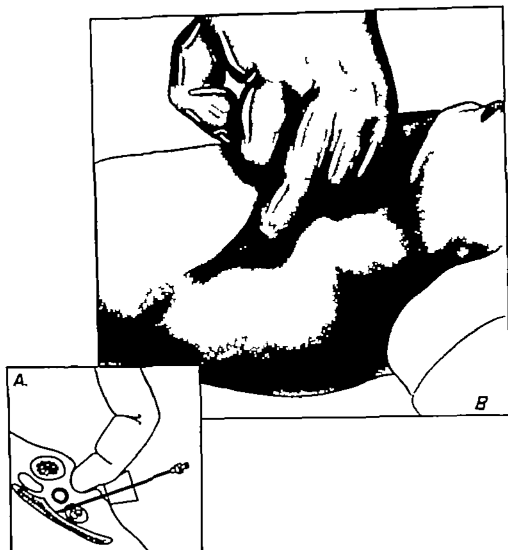


FIG. 23B A. Palpating the pulsations of the subclavian artery as it crosses the first rib the needle through the cork is guided by the palpating finger to a position lateral to the artery and in contact with it. When the needle strikes the first rib, the cork is brought down flush with the skin. This maneuver holds the needle upright and prevents it from pene trating deeper B Palpation of subclavian artery First step in guiding needle to position lateral to it in apposition to plexus.

block. It must be ever kept in mind that the brachial plexus and the subclavian artery cross the first rib in their respective grooves with the plexus lying *lateral* to the artery and in close apposi tion to it (Fig 23 A) As a matter of fact, the artery partially covers the posterior cord of the plexus In performing the block, the operator merely has to keep in mind that both structures cross the first rib together at the midpoint of the clavicle and that the plexus *lies lat eral* to the artery

Technic. Palpate the subclavian artery as it crosses the first rib (Fig 23 B) This is usually at the midpoint of the clavical and one fingerbreadth above it. Raise a wheal at this point, with the finger of the opposite hand palpating the artery and the operator facing the pa

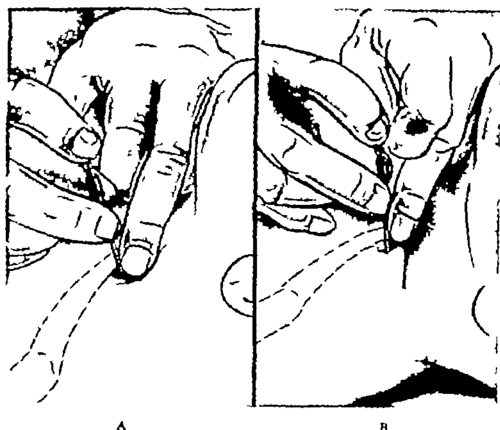


FIG. 23C. A. With finger of opposite hand above the clavicle palpating subclavian artery as it crosses the first rib, the needle through the cork is inserted through a wheal 1 cm. above the clavicle and usually at its midpoint and directed backward inward, and downward to contact the rib. The palpating finger readily guides the needle to its proper place and prevents it from perforating the artery B Insertion of the needle downward, inward, and backward. The needle has been rotated away from its correct position for the sake of clarity

tient. With the arm at the side and the shoulder well down, a 22 gauge 5 cm (2 inch) needle is inserted lateral to the palpating finger and in a direction downward inward, and backward (Fig. 23 C) In thin patients the first rib frequently may be felt beneath the skin and the needle advanced to contact it. On contact, both hands of the operator are withdrawn and the pulsation of the needle (caused by its close apposition to the subclavian artery) is observed If it pulsates well then it is in the close vicinity of the brachial plexus and injections are made at this point without any further movement of the needle If parasthesias are obtained they are useful in locating the plexus but they are not essential to this technic. If the subclavian artery is perforated by the needle point, it should be withdrawn and re directed more laterally Thirty cc (1 ounce) of one or two per cent procaine may be injected through the needle and fractional injections continued by apparatus (Fig 23 E) One per cent may be used if motor power of the arm hand and fingers is desired to be retained, as in suturing severed tendons two per cent will produce a motor paralysis, as well as a sensory block One per cent xylocaine (30 cc —1 ounce)

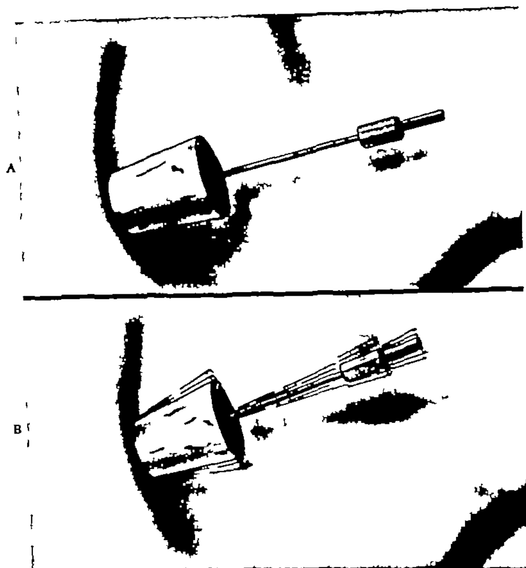


FIG 23D. A. Needle in place in the supraclavicular area. The cork prevents displacement inward and holds it upright. B Pulsation of the needle indicating its close apposition to the subclavian artery If the needle is placed lateral to the artery and on top of the first rib it of necessity is in close proximity to the plexus. Injection of 30 to 40 cc. of one per cent novocain will induce anesthesia within fifteen minutes.

may be also be used. We have found xylocaine very useful for this procedure as it apparently "spreads" more readily than procaine 0 15 per cent pontocaine is also useful and, according to Moore and Bonica, will give anesthesia up to seven hours, thereby rendering the continuous method unnecessary As stated, the arm is blocked most easily at the brachial plexus. It is possible to block the median radial, musculocutaneous, and ulnar nerves at the elbow and the median, ulnar and terminal branches of the radial at the wrist. None of these technics is as easily performed nor gives as good anesthesia as block of the brachial plexus in the supraclavicular area. The brachial plexus block is useful for the reduction of fractures the suturing of lacerations

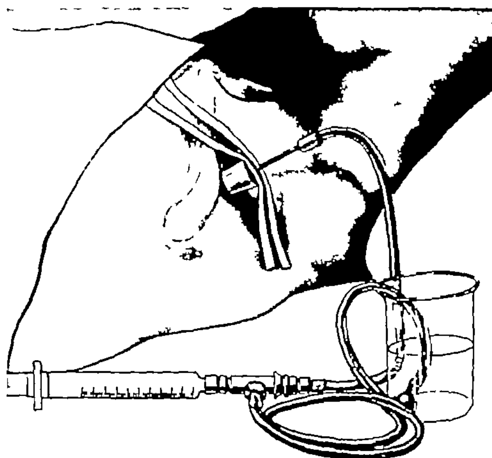


Fig. 23E. Apparatus in place and ready for fractional injections. The adhesive strapping over the cork keeps the needle in place and prevents its outward displacement. The cork firmly holding the needle prevents its inward displacement.

of the skin or of the tendons beneath, or for plastic repairs *e.g.* Dupuytren's contracture As stated, the brachial plexus block is useful also for sympathetic paralysis of the arm for diagnosis or therapy *e g* Raynaud's disease

Finger Block The only procedure which is more easily performed than brachial plexus block is finger block which may be done individually The most useful method is to block the nerves, as they accompany the metacarpal bones. At a point 1 cm above the knuckles and between the metacarpal bones a *large wheal* is raised (for the purpose of blocking the superficial cutaneous nerves) With a 22 gauge 5 cm (2 inch) needle the patient's palm is placed upon the palm of the operator (Fig. 24) All injections are made from the dorsal surface never from the palmar surface The operator's fingers holding the patient's hand palpate the needle which has been introduced through the wheal on the dorsal surface as it approaches the palmar surface The injection is started at this point and 5 to 10 cc. of two per cent procaine or one per cent xylocaine or 0 15 per cent pontocaine are deposited

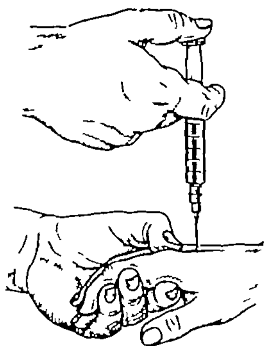


FIG. 24 Finger block. The left hand of the operator holds the hand of the patient with his fingers on the palmar surface. Just above the knuckles a large wheal is made and the needle with syringe attached is inserted perpendicularly between the metacarpal bones until its point is felt just under the skin. Injection is made as the needle is withdrawn. Both metacarpal spaces are injected. For the outer side of the small and index fingers and the thumb the nerves are approached laterally

with the needle withdrawing through the tissues as the injection continues This is done on each side of the metacarpal bone for the three middle fingers For the thumb and small finger the injections are made similarly but approaching the outer surface of the metacarpal The needle must be inserted tangentially to insure blocking of the metacarpal nerves from the outer surface. The finger blocks are useful for operations, *e.g* paronychia skin and tendon lacerations, etc.

Shoulder· The commonest painful affection of the shoulder is subdeltoid bursitis or arthritis when it is acute The intensity of the pain is so great that total disability occurs and the pain is not controlled by simple analgesics It frequently becomes impossible to move the arm for manipulation, and massage is out of the question. Hence blocking of the nerve to the shoulder is the procedure of choice as a complement in the treatment of this disability The block is also useful for chronic shoulder pain The superscapular nerve supplies the shoulder joint (except the skin over it) and forms the sensory pathway from the acromioclavicular joint and the periarticular areas about the shoulder These sensory nerves may be blocked at the lesser scapular notch. The simplest method of suprascapular nerve block has been described by Granirer [8]

TECHNIC With the patient in a sitting position, hands in the lap a line

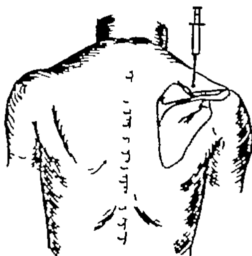


FIG 25 Suprascapular nerve block for shoulder pain by method of Granirer The horizontal line measures 5 cm. from the tip of the acromial process and is projected along the upper edge of the spine of the scapula. At a depth of 4 to 5 cm. the suprascapular fossa is contacted. The scapula notch is then sought and the needle advanced 1 cm. further Paresthesias to the shoulder signal contact with the nerve. Efocaine is useful here for a prolonged effect.

is drawn from the tip of the acromial process along the upper edge of the scapular spine 5 cm (2 inches) in length (Figs. 25 and 26) At a point 1 cm



Fig. 6. Suprascapular nerve block by method of Granirer (Louis W Granirer A Simple Technic for Suprascapular Nerve Block, Courtesy of the N Y State Journal of Medicine)

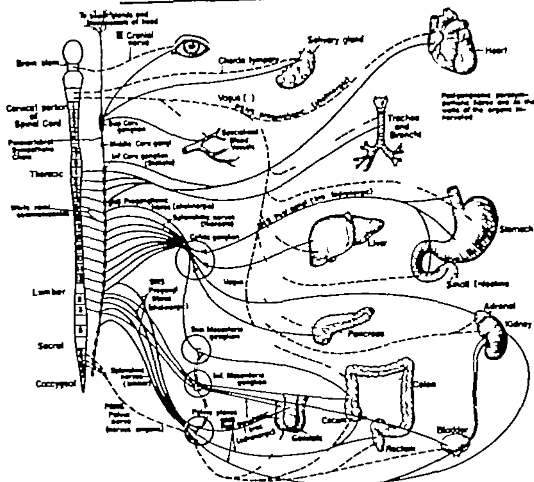
directly above, a wheal is raised and a 7.5 cm (3 inch) 22 gauge needle inserted perpendicularly through it for varying distance of 3 to 4 cm to contact the supraspinatous fossa. A recorder should have been previously threaded upon the needle On contact with bone the recorder is withdrawn 1 cm from the surface of the skin and the scapula notch is sought. When the needle falls into the notch, it should be advanced until the recorder is again in contact with the skin (1 cm) Parasthesias reaching to the shoulder and arm indicate contact with the nerve Five cc of two per cent procaine should be injected and, without withdrawing the needle after waiting ten minutes the patient should be tested for pain by moving the arm If anesthesia follows then 2 cc of efocaine may be injected or 2 cc of ninety five per cent alcohol. Suprascapular block may be done for the purpose of breaking up adhesions of the shoulder joint, but frequently it will be found inadequate Brachial plexus block serves admirably for this purpose

Cervicobrachial Neuritis. This so-called shoulder hand syndrome can be treated with brachial plexus block. This condition is one that usually follows traumatic injury to the arm or hand by high velocity missiles (*e.g* gunshot wounds) or other severe trauma It is somewhat similar to causalgic states. These conditions are best treated with stellate ganglion block and will be considered under the heading of "Sympathetic Blocks" *Sprains and fractures* of the upper extremity may be treated by local injections into the site of the sprain or fracture Solutions used are usually one or two per cent procaine or one per cent xylocaine, 10 to 20 cc as described in the section Lower Extremity

BLOCKS OF THE SYMPATHETIC NERVOUS SYSTEM

The sympathetic nervous system originates in the intermediolateral cell column of the gray matter of the spinal cord lying between T 1 and L 2 or 3 (Fig. 27) This is called the thoracolumbar outflow or division These autonomic fibers pass forward with the anterior somatic motor root and after a short distance separate from the somatic nerve to join the sympathetic gangliated chain through the white rami communicantes. This constitutes the preganglionic fiber of the sympathetic system In the sympathetic ganglia, these fibers may synapse and form post ganglionic fibers which innervate the

THE AUTONOMIC NERVOUS SYSTEM



A———— SYMPATHETIC (THORACOLUMBAR) SYSTEM (SNS)
B- - - - - - - PARASYMPATHETIC (CRANIOSACRAL) SYSTEM (PSNS)
(SNS supply to vessels of extremities not indicated)

FIG. 27 The autonomic nervous system. A schematic representation of the innervation of the viscera by which homeostasis is maintained. In general, cholinergic nerves are the preganglionic fibers of the sympathetic and parasympathetic systems and the postganglionic parasympathetic fibers. Adrenergic nerves compose the postganglionic sympathetic fibers. The fiber to the adrenal gland is preganglionic throughout (therefore cholinergic) and does not form a synapse until it reaches the walls of the gland. Hence, a cholinergic fiber gives rise to the production of adrenin.

various viscera or they may continue through the sympathetic ganglionated chain to the prevertebral or collateral ganglia and form synaptic connections which run through terminal ganglia ending in the walls or structures of the organs composing the viscera. The sympathetic ganglionated chain extends bilaterally from the first cervical vertebra to the seventh, thence along the necks of the ribs in the region of the thorax and along the body of the vertebrae of the lumbar region, to the bottom of the sacrum where they join to form the ganglion impar (unpaired) (Fig. 3) The functions of the sympathetic system

are many and varied. It is necessary to have a knowledge of the physiology of the autonomic nervous system to comprehend fully the rationale of the various block procedures A short review of the anatomy will be given with each procedure The other division of the autonomic system is the parasympathetic or craniosacral outflow which as its name implies consists of cranial nerves III VII IX X (and XI) and sacral II and III This system acts as an opposing force to the action of the sympathetic system and in this way metabolic balance (homeostasis) is obtained From the upper end of each sympathetic trunk a number of branches arise and continue into the skull around the internal carotid artery (internal carotid plexus) The prevertebral or collateral ganglia of the sympathetic are in relation to the aorta and its larger branches There are usually twenty four ganglia in each sympathetic chain, one corresponding to each spinal nerve except for the fifth lumbar and for five of the cervical segments For the eight cervical somatic nerves, there are but three sympathetic ganglia (superior middle and inferior cervical ganglia) supplying them with postganglionic fibers through gray rami which are derived from the cord below T 1 level, since there are no white rami above this level. Also there are no white rami below the L 2 or 3 level and similarly sympathetic structures below this level originate in the cord at L 2 segments and higher

Stellate Ganglion The stellate ganglion is a star-shaped collection of sympathetic nervous tissue which measures 2 x 2 x 0.5 cm and is composed of fibers from the eighth cervical and first thoracic nerves (Fig. 27) It lies at the level of the body of the first thoracic vertebra and sends numerous branches upward and downward in the sympathetic chain Those that flow upward innervate the blood vessels and sweat glands of the face and part of the scalp and control the tone of the muscles of the eyelid. Forming the internal carotid plexus, it sends fibers that run along the ophthalmic branch of the fifth nerve and, as the long ciliary nerve it innervates the dilator pupillae muscle of the eye Stimulation of this nerve causes dilatation of the pupil whereas paralysis of it causes constriction of the pupil. The constriction is produced by the innervation of the sphincter pupillae which is derived from the third cranial nerve (oculomotor) a component of the parasympathetic system. Hence the well known *Horner s syndrome* follows anesthetic injection of the stellate ganglion or any part of the sympathetic chain in the cervical region. This syndrome consists of ptosis of the lid myosis of the pupil and anhydrosis with increased skin temperature on the same side. Nasal congestion on the homolateral side (Guttmann s sign) also occurs when the ganglion is blocked.

THERAPEUTICS Stellate ganglion block may be performed for the following pathological conditions

1 *Embolism of the upper extremity* which causes reflex vasospasm and pain. Stellate block will relieve pain and increase the blood flow through collateral vessels due to paralysis of sympathetic vasoconstrictor fibers in the ganglion with resulting vasodilatation

2 *Thrombosis* or *embolism of the cerebellar* or *cerebral arteries* produces a reflex spasm of the vessels about the area in the brain resulting in an anemia and hypoxia of the area which causes loss of function not only in this area, but in more extensive areas because of the local edema resulting. There is con-

siderable difference of opinion concerning the influence that the cervical sympathetics have over the circulation in the brain It may be true that the vessels coursing in the meninges are controlled by the sympathetics, but there is some doubt whether this holds true for the small vessels in the substance of the brain. Hence, the statement that "the circulation of the brain (and heart) is too important to be at the caprice of the sympathetic nervous system." Therefore the brain may have its own centers for intracerebral vascular control within its own substance. The question is "where?" The surrounding edema and hypoxia are not irreversible if relief is obtained in time (several hours or days)

3 *Causalgia.* This condition is described by its name (heat pain) and is observed most frequently in military practice It usually follows gunshot wounds of the extremities whereby a nerve of the arm or leg is injured, as well as blood vessels. In the arm, the median nerve is most often affected and in the leg, the sciatic nerve. The nerve injury is usually incomplete severance It occurs in approximately 2.5 per cent of nerve injuries and may go to five per cent. The pain may be throbbing or aching in character and described as "vise like" It is usually referred to the distal part of the extremity and is generally located in the palm of the hand or the toes and plantar surface of the feet. It is accompanied by extreme hyperesthesia of the part and great emotional disturbance due to the intensity of the pain.

4 *Painful Phantom Limb and Amputation Stumps:* Nonpainful phantoms are the sequel to a large percentage of amputations of the extremities Some place it as high as ninety per cent, and the phantom may exist for years Severely painful phantoms are much less frequent, but all gradations exist Cramps in the ghost occur with contractions of muscle fibers and severe pain as the result of the contractions and cramping of the fingers, hand or arm (in the upper extremity) and toes foot, and leg (in the lower) Occasionally *neuromata are present in the stump* and may be directly injected with procaine or efocaine

5 *Neuromata Acrocyanosis Erythrocyanosis* and *Hyperhydrosis.* Hyperhydrosis particularly may be benefited by sympathetic block or sympathectomy

6 *Intractable Asthma* (Rovenstine) This is occasionally improved by stellate ganglion block on one or the other side, but do not block bilaterally at the same time.

7 *Reflex Dystrophy* A condition in which the hand becomes damp and cold, resulting in motor weakness and later in atrophy Involuntary muscle contractions cause jerking of the fingers. The difficulty is in diagnosis—the signs and symptoms are all out of proportion to the injury sustained. Several theories have been advanced to explain it.

(a) *Axon reflex. It is thought that* the sensory nerve (afferent) carried an *antidromic (efferent) reflex* i.e., the sensory fiber starts repair processes by vasodilatation This is refuted by the fact that vasoconstriction is the rule rather than dilatation.

(b) *Nocifensor theory* (Lewis) There develops a new type of fiber which produces a new type of chemical substance in peripheral areas of new distribution (a false concept)

(c) *Artificial synapse* The insulation of the nerve fiber is damaged

and results in a "short circuit" or "cross firing" of motor to sensory impulses from the sympathetic fiber to the "C" (pain bearing) fiber What is more probable is that the disturbance is central.

Besides stellate ganglion block reflex dystrophy may be treated by (a) Excision of the local focus (b) Repeated procaine injections at the site (c) Depressing the irritability of the central nervous system by drugs (e g procaine intravenously)

Livingston[10] has laid down some useful rules

1 Never underestimate the patient s complaints

2 Don't force physical therapy if the patient is worse

3 Repeated procaine blocks of "trigger areas "

4 Reserve brain operations as a last resort.

5 Keep records and be critical of end results

Technic of Stellate Ganglion Block The easiest technic for approaching the stellate ganglion is the anterior method For affections in the upper limb and face (phantoms Raynaud s etc) the ipsilateral side is blocked for cerebral vascular conditions resulting in paralysis of limbs the contralateral side to the paralysis The trachea is palpated as well as the pulsations of the common carotid artery at a point two fingerbreadths above the sternal notch and in the space between the trachea and artery a wheal is raised (Fig. 28) A long needle is passed through this wheal and directed perpendicularly downward until bone is contacted. This latter structure is the vertebral body of C 7 or D 1 The needle is withdrawn slightly so that the injection is not under the periosteum and, after careful aspiration for blood or spinal fluid injection of 10 cc of one or two per cent novocain or one per cent xylocaine is made A waiting period of ten to fifteen minutes should follow and a Horner s syndrome (see Stellate Ganglion) should become evident in this time if the ganglion or any part of the cervical sympathetic chain has been reached If a longer block is desired, 2 to 3 cc of efocaine may be distributed in different areas up and down the vertebral body

Cardiac Pain The pain originating in the heart may be treated occasionally by sympathetic block. Conditions in the heart that cause pain in the region of the chest and one or both arms are due to angina pectoris or coronary thrombosis and it is necessary to block the stellate ganglion and D 2 3 and 4 on the same side as the pain (usually the left) The stellate may be blocked by the procedure described above and the T 2 3 and 4 sympathetic ganglia by paravertebral injections These must be done with ninety five per cent alcohol. Our experience however has shown that the dorsal sympathetic ganglia may be most effectively blocked by the use of an epidural catheter at appropriate levels and the injection of fifty to ninety five per cent alcohol (see Epidural Block) Procaine injections directly into the "trigger areas" on the thoracic wall in cases of acute or chronic cardiac pain have occasionally proved useful Travell and Rinzler have noted the resemblance of pain in the chest muscles to angina and myocardial infarction In three case reports they emphasized this possible relationship and suggested local procaine infiltration or ethyl chloride spray[11] Generally there are one or more "sore" spots which are apparent

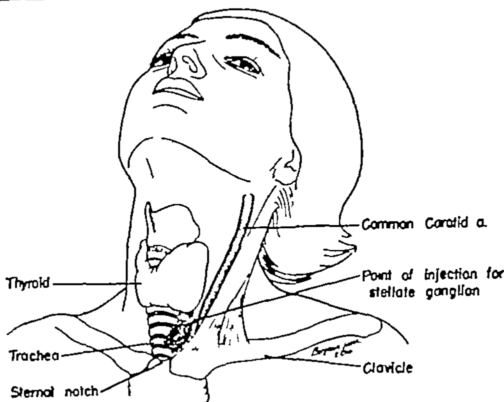


FIG. 28 Stellate ganglion block. (Modified method of Steinbrocker) The sternal notch is palpated and lines are drawn from it along the outer border of the trachea and along the medial border of the common carotid artery Two fingers above the notch and in the middle of these boundaries a wheal is raised and a 22 gauge, 7.5 cm. (3-inch) needle advanced perpendicular to the skin to contact bone (body of C 7 or D 1 vertebra) Ten cc. of two per cent procaine are injected, after careful aspiration for blood and spinal fluid is negative, and a Horner's syndrome should develop in ten to twelve minutes.

(areas of hyperesthesia) during an attack. They may exist in any locality on the chest wall, anterior or posterior and vary in size from one to several square centimeters Using a syringe with a hypodermic needle attached, procaine one per cent (or efocaine for long duration) is injected under the fascia at the site (2 to 3 cc) All painful areas must be injected. In a few cases it was astounding how fast the pain disappeared. The injections may be repeated if the pain returns (see Chest Pain)

Travell[13] advocates the use of *ethyl chloride spray* for these conditions, as well as painful neuromuscular conditions The area to be sprayed is carefully determined and, taking care that there are no fire hazards present and that the patient is protected from inhalation of the vapor the spray is applied to the area, not directly but on a tangent in sweeping motions in one direction only being careful not to frost the skin. In Travell's wide experience and occasionally in the writer's, this has proved valuable with immediate abatement of pain.

Lumbar Sympathetic Block. Ochsner and DeBakey first called attention to the importance of interrupting efferent sympathetic stimuli to the lower extremity in cases of peripheral vascular emboli, thrombosis, or chronic vascular diseases The rationale is on the basis of inter

rupting the vasomotor reflex through the spinal cord and sympathetic chain. As a result of impulses originating in the thrombosed venous segment, there are three dominant factors viz. venospasm extensive coagulation, and arteriospasm Venospasm is most constant and significant By blocking the sympathetic ganglia, the vasomotor reflex is broken and clinical manifestations are relieved. Ochsner believes the manifestations are due less to the associated venospasm than to an arterial spasm If the condition is amenable to block therapy it is rarely necessary to do more than three injections—often, relief is obtained after one injection Within twenty four hours the temperature declines while it frequently becomes normal in seventy-two to ninety-six hours Swelling begins to diminish in the first twenty four to twenty-eight hours and in seven to ten days disappears entirely In half of the cases the extremity returns to normal within four days after treatment has been started. Most thromboses involve the lower extremities probably because of their relative inactivity postoperatively

Technic—Method I

1 Raise intradermal wheals at 2 to 2½ fingerbreadths lateral to the upper point of the spinous processes of L 1 2 3 and 4 on the appropriate side (Fig 18) Insert a long needle with recorder vertically until the point impinges on the transverse process (4 to 5 cm.)

2 Change direction (either up or down) so that the needlepoint can project beyond the process and is in a direction slightly towards the midline

3 The needle is then inserted for another 2½ fingerbreadths so its point impinges against the anterolateral surface of the vertebral body between the vertebra and the retroperitoneal space

4 Inject 5 c. of two per cent procaine or 2 cc efocaine through each of the four needles so placed, after first making sure the point of the needle has not penetrated the subarachnoid space or a blood vessel.

Method II This is more easily performed At a point 7 cm lateral to the upper border of the spinous process of L 1 2, 3 and 4 wheals are raised (Fig 6) Using a long needle with marker threaded through it, it is advanced at an angle of forty-five degrees with the midplane of the body to directly strike the body of the lumbar vertebra thereby by-passing the transverse processes. The usual depth of the needle at this time is 8 to 9 cm beneath the surface After striking the body the hub of the needle is deflected towards the midplane and advanced so that the bevel slides forward and off the body of the vertebra This determines that the point of the needle is just beyond the anterolateral part of the body of the vertebra. The recorder is set flush with the skin and the needle withdrawn 1 cm as indicated by the recorder being that distance from the surface of the skin. This maneuver will bring the point of the needle back to the anterolateral portion of the body of the vertebra at which point the lumbar sympathetic chain is located. Five cc of two per cent procaine or xylocaine are injected through each needle and if the needles are well placed and the vascular supply of the leg is capable of being relaxed, the skin of the foot will become warm and also dry because of the blocking of the sympathetic vasoconstrictor and sudomotor impulses. Two cc. of efocaine may be injected at each level in place of procaine or xylocaine.

Method III With the patient in the upright position the spinous process of L 1 is located and 4 cm. lateral to this location a wheal is raised and the needle is inserted through it perpendicularly to contact the transverse process of L 1 The recorder is now withdrawn from the skin, 4 cm and the needle reinserted *in a downward, inward and* forward direction to contact the body of the L 1 vertebra (Fig. 3) After care*ful aspiration, 50 cc of 0.5 cm per* cent procaine is injected through the needle and the patient supported in the sitting position for twenty minutes This method is not very accurate, but occasionally gives results

Method IV A Touhy catheter is inserted into the lumbar epidural space between L 2 *and 3 and advanced 5* cm. One per cent procaine is injected through it. Usually 10 to 15 cc is sufficient. The catheter may be left in place and fractional injections of procaine made through it every six hours (10 to 15 cc.) or a bottle of one per cent procaine may be connected with the indwelling epidural catheter and a continuous drip instituted the speed of the drip being regulated for individual requirements (usually 5 to 10 drops per minute)

In peripheral vascular conditions it is recommended that lumbar sympathetic block with procaine be performed every six hours for maximum results. This causes distress to the patient if done by any other method than by indwelling, epidural, or paravertebral catheter

Method V—Continuous Spinal Anesthesia. With a Touhy catheter in the subarachnoid space, at L 2 to 3 interspace, continuous spinal anesthesia prolonged for days has been used to effect sympathetic nerve block and relieve pain of peripheral vascular injury [12] or for vasospastic disease of the lower extremity a mixture of a long acting agent and a vasoconstrictor has been used.* In the writer s case seventy two injections were given through the catheter over a period of eleven days and resulted, following surgical repair in com*plete recovery of the limb following* popliteal artery injury In two other cases, the anesthesia was prolonged for *seven days and fourteen days respec*tively Although these prolonged anesthesias were not marked by any untoward signs we now employ continuous epidural block as a safer method.

Method VI—Continuous Paravertebral Lumbar Sympathetic Block. A Touhy catheter is passed through a large bore needle to the sympathetic chain at the level of L 1 and after withdrawal of the needle the catheter is strapped in placed and fractional injections of two per cent procaine or xylocaine are made through it (Figs 29 30 31 and 32)

Low Back Conditions: On many occasions anesthetic injections will relieve pain which is localized *in the low* back or is combined with sciatica. Although efficacious and sometimes dra*matically so there is little* understanding regarding the mechanism by which relief is obtained. Careful examination to exclude the presence of a *ruptured* intervertebral disk, tumors of the cauda equina or osseous infections or new growths must be made before deciding upon injection therapy Low back conditions are familiar to all *physicians* ranging from lumbago to sacroiliac *strain* To be amenable to injection

---

* 20 mg. nupercaine 1 to 200 2 cc., ten per cent glucose 3 *cc., 150* mg. ephedrine, 3 cc., 500 mg. novocain crystals aq dest., qs. *10* cc. Two cc. of this solution are injected at four to five-hour intervals.

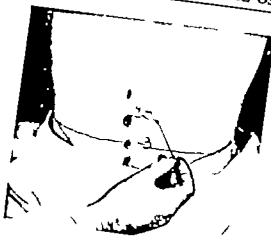


FIG. 29 Continuous paravertebral lumbar sympathetic block. Step 1 4 cm. lateral to the spinous process of L 1 a wheal is raised and 16 gauge needle inserted to the lateral portion of the body of the first lumbar vertebra.

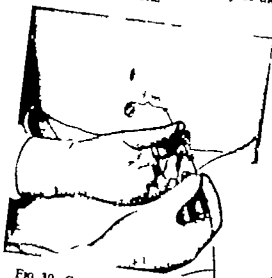


FIG. 30 Continuous paravertebral lumbar sympathetic block. Step 2. With the needle point in contact with the vertebral body a Touhy catheter is threaded through it until the resistance of the tissues is felt. The needle is withdrawn leaving the catheter in place.

treatment, the physician must determine the presence of tender spots (areas of hyperalgesia) at one place or another over the dorsal or sacral regions of the body Travell has worked out these "trigger areas" and their radiations and has determined that for each area there is usually a well determined zone of radiating pain. Upon finding a tender spot or trigger area, the following Postulates of Steindler and Luck[14] to establish a causal relation between the trigger point and the radiating symptomatology must be established.

1 Contact with the needle must aggravate the local pain

2 Contact with the needle must elicit or aggravate radiation.

3 Procaine infiltration must suppress local tenderness

4 Procaine infiltration must suppress radiation.

5 Positive leg signs must disappear (in lower extremity pain)

In the writer's experience the commonest site of a trigger area is over one or other posterosuperior iliac spines If there is tenderness here with low back pain and disability accompanied by sciatic radiation and the Postulates of Steindler and Luck are manifest, the condition is frequently improved or "cured" rapidly It is usually necessary to inject the areas more than once (two to three times a week) before complete amelioration is effected. Usually 3 to 5 cc of one per cent procaine or 1 to 2 cc. of efocaine are injected fanwise about the area and light massage over the site instituted to effect spread of the solution No adhesive strapping or other support is used

The Multifidus Triangle (Post division Syndrome) Livingston in his Pain Mechanisms[10] described this syndrome and its possible causal relationship to low back pain The multifidus triangle is an inverted right angle triangle the base extends from the midline to the posterior superior iliac spine the apex is the lowermost point of origin of the multifidus muscle The posterior primary divisions of S 1 2 and 3 sup-

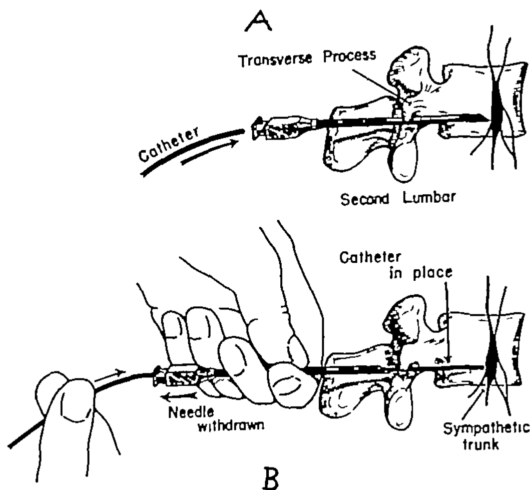


FIG. 31 Continuous paravertebral lumbar sympathetic block. Step 3
A—Needle at side of body of vertebra.
B—Catheter passed through needle and its end in proximity to the lumbar sypmathetic chain.

ply the structures within the triangle The multifidus muscle is the second layer of the transversospinal musculature and extends from the sacrum to the second cervical vertebra. It is best developed in the lumbar region and least in the thoracic. It acts to stabilize the spine in its relation to the sacrum. The supposed mode of action is that the sensory fibers within the triangle are irritated and set up reflex disturbances which reach the spinal cord and provoke an "area of hyperirritability" which in turn sends out stimuli to other areas of the back innervated by this segment or segments of the cord. This is what Livingston calls the "Internuncial Pool," *i.e* the connecting fibers in the gray matter which are the synaptic mediators of stimuli between groups of fibers It is his theory that these fibers are disturbed or disarranged and that a "vicious circle" is instituted, being kept in operation by the continuous bombardment of the cord by the afferent stimuli coming from the "trigger area." Local anesthesia to the trigger area stops the bombardment temporarily and lasting effect or improvement results, because during the time the anesthesia is de-

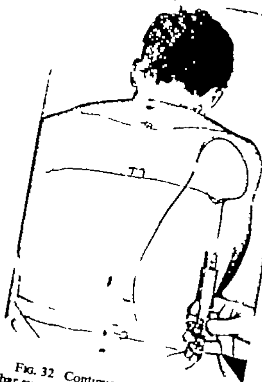


FIG. 32 Continuous paravertebral lumbar sympathetic block Step 4 A catheter is strapped in place and attached to a syringe for fractional injections. A sterile test tube held to the chest by adhesive may be used to hold the needle and end of the catheter between injections. Usually 10 cc of two per cent procaine are injected at four hour intervals. (Figs. 29 to 32 from Ambro and Mendoza Continuous Paravertebral Lumbar Sympathetic Block, Courtesy of Missouri State Journal of Medicine)

pressing the sensory stimuli the "Internuncial Pool" is rearranging itself Following this "rearrangement," the syndrome of pain and muscle spasm is broken and does not recur Procaine one or two per cent (5 to 10 cc) may be used and repeated bidaily or efocaine 3 to 5 cc. spread out in a fanwise manner being careful not to pool the solution.

In our pain clinic we have found the blocking of the multifidus triangle frequently effective in relieving low back pain and disability One case stands out —

CASE REPORT A thirty-six year old white male had been injured at work five years previously by bending over and attempting to lift a heavy object. He experienced a severe pain in the lumbar region, radiating down his left leg and was disabled. Over a period of five years he had the full complement of treatment consisting of traction, plaster spicas, manipulation under anesthesia, and complete bed rest These treatments were repeated over the years and did not produce any improvement. He came to the clinic in obvious pain and a severe limp Examination disclosed the usual signs of low back pain and sciatica Tenderness over the multifidus triangle was elicited and 5 cc. of one per cent procaine were infiltrated beneath the aponeurosis of the sacrospinalis muscle into the multifidus muscle The patient experienced immediate and dramatic relief Practically all signs of his disability disappeared and he left the office free of pain and without limping. He had two more injections at the same site and returned to work within two weeks There was no recurrence

Sacroiliac Syndrome Pain and disability due to this condition is very frequently found Careful examination must be made to rule out the presence of ruptured lumbar intervertebral disks and other conditions The pain is usually due to subluxation of the joint and may be acute or chronic Anesthetic injections about the joint occasionally may help the sufferer but they usually are ineffective In subluxation the best treatment is that described by Travell which is a manipulation aimed at reducing the luxation On a hard table the patient lies on the affected side with the

upper foot around the heel of the lower The operator facing the patient, places the palm of one hand on the upper ischeal tuberosity and pushes upward and forward while the other hand on the patient's shoulder pushes backward thus effecting a "corkscrew" motion Pressure should be sustained and the maneuver is often accompanied by a "snap" indicating the reduction. Relief is obtained immediately in those cases in which the pain is due to simple subluxation.

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45

Fractures of the Spine and Pelvis

FRACTURES OF THE SPINE

THE percentage of tragic deaths and hopeless cripples is small when compared to the great number of excellent results following spinal injuries. Nevertheless, we must increase our efforts to reduce this small percentage even further Indeed, many examples can be cited where paralysis and death have been inadvertently caused by improper handling of a nonparalytic case at some point between the time of accident and the first week in the hospital Furthermore patients can be made worse by careless surgical treatment. Utmost vigilance and meticulous attention to detail will be rewarded promptly in the most serious as well as the trivial cases

GENERAL OUTLINE OF TREATMENT

First Aid All emergency and first aid workers whether in hospitals factories or public places should be thoroughly drilled in the simple lifesaving rules to follow in spinal injuries. Any person who meets with an accident and who has pain in his back with difficulty in standing or walking should be immediately stretched out on the floor ground couch, or bed in the straight position from head to toes, preferably on his back because it is dangerous to place him in the prone position in case of cervical spine fracture He should never be lifted like a sack of potatoes by shoulders and legs with sagging of spine The back should be held straight as a broomstick

An ambulance should be called to avoid transportation in any other position The patient is kept comfortable while waiting for medical assistance Covering with a blanket or other material will minimize shock and reduce muscle spasm The patient is reassured to relieve nervous tension Warm liquids can be given by mouth

All of these measures will help to relax the patient and indirectly prevent unnecessary rise of intraspinal pressure, which is not desirable in case of cord injury

History Taking The ambulance surgeon should take a quick history and make a rapid physical examination to determine any change in the patient's symptoms since the moment of injury The head and neck are gently examined for cervical spine injury because head injuries are often associated with neck fractures The movements in the arms and legs are tested The location and distribution of pain, numbness or paresthesias are noted Any leakage from urinary bladder or bowels is noted.

Sedation Morphine may be given sparingly but only if there is pain It is depressing and may increase abdom

inal distention Barbiturates are better

Open Wounds. These are covered with sterile dressings

Transportation This is the second important step in the treatment because damage can be done by one false movement.

The first important step is in stretching the patient out without flexing him at the time of the injury Several people are needed in order to move the patient safely especially if the cervical spine has been injured. A competent person is assigned to hold the head straight, adding a little traction so that the head and neck move in one piece with the body and always avoiding flexion in all neck or back injuries. If the neck is not involved and the patient is conscious, he can be rolled on to a stretcher like a carpet and placed face down to extend his spine Remember that a person with a large abdomen will obtain flexion of the spine instead of extension, if the stretcher is firm enough. For this reason and because of possible neck fractures in dazed patients, it is recommended that all cases be kept rigidly straight and flat on their backs without flexing the neck or lower spine It is easier to remember this position and it is safe

A firm stretcher ladder splint, rigid board, or narrow door can be used. A ladder splint can be improvised by tieing pieces of lumber in the design of a ladder if one of proper length is not available. The patient is then lashed to the ladder or board for transportation He is lifted gently into the ambulance and taken to the hospital.

X-rays. If there is any evidence or possibility of paralysis it is not advisable to take x rays. The patient is taken to bed directly using the same precautions when transferring *him to the* bed. Four people are necessary to avoid any possible damage to the spinal cord He should not be thrown on to the bed or twisted in any way X-rays can be taken later with a portable machine Adequate lateral and anteroposterior views should be obtained Sometimes it is safe to take x rays on the stretcher before putting the patient to bed if a responsible doctor is present to prevent careless handling by technicians

Position in Bed The patient is placed flat on his back with a small blanket roll under the dorsolumbar area and sandbags around the head to support whatever area appears to be involved, until more definite treatment can be given.

Neurological Examination Rapid neurological examination must be done before starting treatment in order to follow the progress of the injury If the examination is delayed, even for one hour it could prevent discovery of a sudden or even gradual change in the sensory and motor signs which, in turn might indicate some type of cord hemorrhage, requiring immediate decompression laminectomy The prognosis is often decided by the progress of symptoms from hour to hour

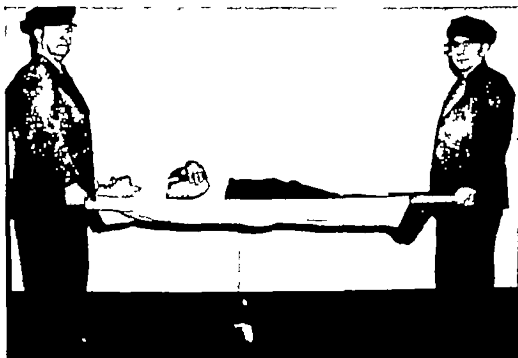
The patient is first asked to move arms hands, legs and feet in all directions methodically If he cannot raise his extremities the examiner raises each member off the bed and lets it fall abruptly in order to test muscle power Sensory response to pinprick and temperature changes, using test tubes filled with hot and cold water is noted along *the extremities* and trunk.

Symptoms of complete *interruption* of continuity in the cord, indicating transection, cannot be accurately evaluated early because of spinal shock which can show the same signs of complete



A.

FIG. 1A A method of transferring patient to stretcher in straight position protecting the neck and dorsolumbar spine with the forearm of the attendants behind the neck back respectively



B

FIG. 1B Carrying patient on ordinary stretcher It is easy to remember the straight position especially if patient is in coma or stupor

motor and sensory paralysis as transection but the symptoms are temporary in spinal shock lasting only a day at the most. A simple test which will indicate whether or not any impulses are going through the injured area up to the brain is done by squeezing the big toe joint between the examiner's fingers, using enough pressure to cause severe pain in the normal person If any response is obtained it indicates that the lesion is not complete even when all other motor and sensory reflexes are lost, as described in Bastian's Law Remember that during the first few hours of spinal shock the signs can be the same as in complete severance of cord, with total absence of any response Sensation is gone and muscles are totally flaccid.

However after the first day there must be some improvement in the neurological signs because spinal shock is no longer present. Priapism or erection of penis is often a sign of severe cord or caudaequina damage, but it is not always a serious sign. Complete loss of all sensory and motor power with persistent flaccidity of muscles and total incontinence of urine and feces indicates a hopeless transection of the cord or caudaequina.

When the lesion is partial, there will be changes in the reflex pattern with return of some control over bowels and bladder the Babinski sign will appear the flexor reflex is noted and there will be some general improvement in motor power or sensation

If patellar reflex and ankle clonus return within the first week, complete recovery can be anticipated Pain and temperature sense is tested in the extremities to determine presence of Brown Sequard syndrome in the spinal cord, not in caudaequina. Pain and temperature will be impaired on the opposite side of the injury whereas some motor power with spastic reflexes will be noted on the same side as the lesion. The upper motor neuron is involved in the cord above the level of the cauda equina. There is gooseflesh sweating of skin at sensory level.

In the lumbar spine below the first lumbar vertebra there are only lower motor neurons making up the caudaequina and the signs will consist of flaccid muscles, depressed or absent reflexes, and sensory changes around the saddle area Pricking the perineum with a needle will give information concerning involvement of caudaequina.

The end of the cord and the beginning of the caudaequina are crowded together at the twelfth dorsal and first lumbar vertebrae Injuries at this level give mixed symptoms of flaccidity and spasticity The lack of space causes serious damage following injuries at this level.

The prognosis is much better in cauda equina injuries than in those of the spinal cord because it is made up entirely of peripheral nerves which have the power to regenerate, whereas, spinal cord tissue never regenerates once it is destroyed. Whatever improvement takes place in the cord is due to the prompt relief of pressure from the part of the cord which has not been damaged. It is assumed that maximum cellular damage occurred at the moment of injury and improvement will take place by dispersal of hemorrhage reduction of edema, prevention of further bony deformity and correction of existing deformity if indicated.

General Examination. Other injuries, both visceral and skeletal, including the head, chest, abdomen and extremities, should be carefully tabulated

with proper evaluation of the general condition Appropriate emergency measures should be instituted and immediate consultations obtained to minimize the effects of shock and to save the patient's life in case of a ruptured viscus

Whole blood plasma and fluid electrolytes are given as necessary, allowing 4000 cc of fluids every twenty-four hours, if patient is unable to take them by mouth. Heroic measures to combat abdominal distension are often necessary to turn the tide in favor of the patient. If the bladder is paralyzed, an indwelling catheter is inserted and tidal drainage started when needed.

Spinal Tap and Queckenstedt Test These procedures should be left to the judgment of a neurosurgeon or other competent specialist because irreparable damage can be done while turning the patient (or even while inadvertently removing spinal fluid in case of associated head injury during the procedure, whether in the cisterna magna or lumbar area of spine) This test is necessary to determine the presence or absence of spinal block when symptoms are stationary or getting worse. If a block is discovered and if it cannot be relieved by closed methods such as hyperextension in the dorsolumbar fractures then one must consider laminectomy The position of hyperextension *in dorsolumbar fractures is considered* as a method of reduction by combining angulation with postural traction over a fulcrum represented by the arched support which divides the body in two equal parts exerting some pull in opposite directions

In cervical spine fractures one can obtain closed decompression by padded halter traction to the chin skeletal traction to the skull or simple sandbag support behind the neck and around the head to prevent rotation from side to side

Open operations of any kind cannot be done while patient is in shock and no emergency spinal operation can be contemplated until certain rigid requirements have been met. The cervical cord is not ready for surgery before one week, the dorsal cord is not ready for several days, but the caudaequina is different because it is made up of peripheral nerves and can be explored within two or three days if necessary Shock is less severe in this area, but abdominal distension is troublesome

Always encourage patient by showing great satisfaction at the least amount of improvement and never show disappointment at lack of progress An optimistic attitude will be appreciated by the patient even if he suspects the worst. Very often, the doctor is more surprised than the patient, when an unexpected, remarkable recovery is made It is not quite fair to let the patient cheer-up the doctor and indeed, this occurs with some of us Whether we call it the art of medicine or psychosomatic medicine it makes no difference it is part of our armamentarium and there is a definite place for it in our field of endeavor Cheerful, *as well as efficient and skillful* treatment will speed recovery If the patient is ornery and ungrateful we must be *more firm* in our attitude to obtain cooperation If a psychosis develops or is imminent a psychiatrist should be called promptly

Classification of Cord Damage

Spinal Shock: This is a temporary state of paralysis which may be of varying degrees from a mild, partial paralysis to complete paraplegia characterized by total absence of muscular and sensory response paralysis of bladder and

bowels, or loss of reflexes Function re turns within twenty four hours

Concussion Without entering into controversial discussion this can be de scribed as a form of spinal shock with the possibility of petecchial or other form of hemorrhage occurring any where about the cord or its meninges.

Contusion This may cause hematomyelia, involving the substance of the cord or subarachnoid hemorrhage on the surface of the cord. Some improve ment is noted early and within twenty-four hours, but symptoms may become stationary or become worse

Laceration This implies varying degrees of destruction of cord tissue with hemorrhage No improvement is seen for several days and progress may be prolonged over a period of weeks or months.

Transection This term indicates complete severance of the cord with no possibility of improvement. Initial spinal shock with flaccidity is replaced by symptoms of spastic paraplegia with automatic bladder if the patient does not die of intercurrent infection.

Epidural Hemorrhage: This is usu ally localized to the site of bony injury and disperses itself unless bony encroachment on the cord is not relieved, either spontaneously or by treatment Symptoms are dependent on the degree of cord damage.

Localized Subarachnoid Hemor rhage: This condition is similar to epidural hemorrhage in that bony encroachment against the cord can prevent dispersal of the blood. The symptoms are the same as in hematomyelia where gradual increase in hemorrhage will cause a corresponding increase in pressure against the motor and sensory tracts of the cord, with progressive loss of muscle power and sensation.

The difference lies in the absence of root pain with hematomyelia, whereas, in subarachnoid hemorrhage there is root pain at first, but gradually diminishes if the hemorrhage compresses the sensory tracts of the spinal cord.

Hematomyelia This is an interest ing subject because of the speculation which it can arouse concerning its re lationship to seemingly trivial injuries Its occurrence in the normal cord after serious fractures and dislocations in the vertebral column is well understood The mechanism of production is also clear in the disease known as syringomyelia where cystic cavities are already present in varying numbers in the spinal cord, becoming filled with blood follow ing a minimal or major injury How ever it is commonly known that spontaneous hemorrhage without trauma can occur in syringomyelia, whereas, it is ex tremely rare in the normal cord and would occur with minor injuries only in case of some vascular malformation or small aneurysm. Indeed, some authors feel that the cavities of syringomyelia are developmental in origin and may be present at birth It is sometimes difficult to determine even at operation whether or not the cavity is one of syringomyelia, if no symptoms of the disease were present at the time of the injury The younger the patient the lesser the chance of finding evidences of the disease at the time of accident.

The common symptoms of syringomyelia are anesthesia of fingers atrophy of small muscles of the hand, and pathological reflex changes As a general rule, the findings are clear cut in hema tomyelia because of the absence of pre existing symptoms and the sudden onset of cord pressure signs following trauma in an apparently normal person.

Some authorities maintain that symp-

the commissure, but this is not recommended, in general. Postoperatively treatment of bony injury continues whether hyperextension for dorsolumbar fractures or skull traction for cervical fractures is used. Later on it may be necessary to immobilize the spine in a brace to get the patient out of bed. When bone injury is healed, physiotherapy and rehabilitation is continued, remembering that these aspects of treatment start from the first day of injury to prevent contractures, vascular complication and mental depression. Light massage with talcum powder avoiding damage to the insensitive skin and moving all joints through their normal range of motion every day both passively and actively where possible will help immensely to prevent contractures.

Caudaequina Injuries. The conus medullaris and all the nerves of the caudaequina are snugly fitted in the spinal canal at the lower border of the first lumbar vertebra where the cord ends and the lumbosacral nerves begin. The cauda gives rise to the third, fourth, and fifth sacral segment and first coccygeal.

Injuries at this level are serious because of the small space occupied by these structures making them susceptible to rapid destruction when pressure from bony injury or hemorrhage within the conus exists. Injury to the conus is almost hopeless and caudaequina lesions are very serious at this level. Lower down, there is more room for the nerves and recovery is more likely. Compression, lacerations, contusion, stretching, or division are less common in the lower portion. Conus injuries will show combined symptoms of spasticity and flaccidity plus presence of pain in the lower extremities which does not occur in pure cord injuries higher up.

Pain in the legs is a symptom of caudaequina injury. Bladder sphincter, and genital symptoms are more intense in conus injury. Trophic changes are also commoner. Because of the powers of regeneration of the peripheral nerves and because we can prevent scarring fibrosis or gliosis, and entanglement and matting of nerves from organization of hemorrhage, operation is often indicated in lumbar injuries where symptoms do not show spontaneous improvement within a few days.

Laminectomy is often necessary to repair lacerated nerves. In caudaequina lesions, we cannot be guided by the Queckenstedt test for spinal block. The type of bone injury and the lack of improvement in neurological symptoms, are the determining factors regarding surgical intervention. If signs are stationary or getting worse operation is indicated. If no surgery is indicated, the general treatment is the same as for paraplegia. Recumbency on an air or rubber foam mattress, frequent turning on the sides several times daily, good nursing care to prevent bed sores, attention to bedding, avoiding moisture and watching of bowel and bladder function are the salient features besides general medical supervision.

The Strycker Frame is a useful type of bed and allows turning of patient like a griddle cake, without any discomfort.

Surgical Anatomy of Spine

There is a greater range of *motion* of the entire spine in forward flexion, *than* in lateral flexion to either side or in extension. These factors are due to the structural arrangement of the joints and ligaments. The posterior articular processes are placed in a coronal plane to limit extension. The superior processes of the lower vertebra lock in front of the

inferior processes of the vertebra above and this allows relatively limited motion backward beyond the erect position Their resistance to extension is augmented by the powerful cable-like anterior longitudinal ligament in front of the vertebral bodies and by the strong annulus fibrosus around the intervertebral disk and entire marginal circumference of the adjoining vertebral bodies

The ligaments which prevent flexion are also quite powerful, but there is more elasticity to allow motion in forward flexion Thus may be a protective mechanism for the abdominal viscera The interspinous ligaments ligamentum flavum interarticular and posterior longitudinal ligaments are all located behind the vertebral body to strengthen the neural arch which holds the spinal cord The nucleus pulposus is located anteriorly but its cushioning or shock absorber action also limits flexion. At this point the annulus fibrosus acts as a strong-walled elastic chamber to prevent the nuclear material from popping out of its chamber We can easily see that the annulus fibrosus has two opposing functions and performs them well It is actually a separate structure around the nucleus pulposus whose elastic compressibility allows forward flexion up to a certain point, beyond which it will stop motion and then act as a pivot or fulcrum if the flexing force does not stop Beyond this point, crushing of the bone begins at the anterior margin of the vertebral body causing a minimal wedge compression or chip fracture If the flexing force increases the crushing component spreads posteriorly causing wedge compression of the centrum or body with protrusion of nuclear material into the bodies and neural canal. Decompression of the nucleus into the body prevents paralysis by keeping the nucleus away from the neural canal.

If flexion is continued by the injuring force there will be rupture of the interspinous ligaments and the ligamentum flavum between the laminae leaving the weak interarticular ligaments the responsibility of preventing dislocation.

On the other hand if a new component of force is added such as compression there may occur a crushing of the entire body with concentric spreading, causing the posterior border of the vertebral body to move backwards towards the neural canal and cord This sometimes happens in elderly people with osteoporotic vertebrae and younger individuals following severe accidents or falls from great heights

When other forces are added, such as rotation and lateral flexion, the bone may show some evidence of dislocation or lateral compression fracture

When the force is reversed to produce hyperextension, the spinous processes and posterior articulations jam together while the anterior longitudinal ligament holds fast. When this ligament ruptures the vertebral body is pulled apart by the annulus fibrosus and the anterior ligament while the posterior joints or laminae may fracture and encroach on the cord posteriorly These hyperextension injuries are rare

The only true diarthrodial joints are the posterior articular processes and these have elastic ligaments which allow considerable excursion with forward flexion These are the joints which can lock after separating and remain in one of two positions They may become stuck in a "perched," (Watson-Jones) nose-to-nose kissing, etc., position or they can overlap in a reversed relationship with the inferior processes of the



FIG. 2A. Central body fracture fracture-subluxation of posterior facets. Treated in bed for cord bladder and fractured hip which was nailed in four weeks following traction.

upper vertebrae slipping forward and downwards under the *superior processes* of the vertebra below

The ligamentum nuchae and inter spinous ligaments posteriorly with the anterior longitudinal ligament in front, are a great help to the patient and surgeon in the treatment of bone injuries of the cervical spine They allow a great amount of traction without danger of pulling the cord apart. We must preserve the ligamentum nuchae when performing open reduction or laminectomy in neck injuries The anterior longitudinal ligament and the intact posterior articular processes are the key to reduction of vertebral fractures by hyperextension. Without the checking and molding of the ligament and the blocking action of the posterior *joints* the patient would be in constant danger of death from cord damage when hyper extending or stretching the spine How ever there is no danger of *injury to*

the cord unless there is an unrecognized fracture of the neural arch, a dislocation or a crush fracture of the whole body with encroachment on the neural canal In hyperextension injuries it is of no help and it may be ruptured. However it is a reassuring, important structure in reduction of fractures in the cervical spine when straight traction may be needed in a hyperextension injury In this area, the anterior longitudinal ligament and ligamentum nuchae usually remain intact.



Fig. B. Excellent recovery but needs posterior fusion operation for residual static pain.

The discovery of these anatomical facts spurred the surgeon to renew his efforts in obtaining more accurate anatomical reduction with increasingly good results. For many years the principle of hyperextension was adhered to rigidly in the treatment of flexion fractures of the vertebral bodies The anterior ligament and the posterior articular processes prevented catastrophes during reduction. The experienced surgeon recognized hyperextension injuries and applied a plaster jacket in the neutral or straight position. However there have been many cases which have been treated in the straight position either in bed or in a plaster jacket for many reasons If the x ray films were unsatisfactory or the surgeon had difficulty in their interpretation the patient was kept in bed until it was safe to get him up with a plaster cast or brace usually from four to six weeks This has been done in many cases of difficult fracture-dislocations with instability and apparent disorganization of posterior bony elements Whether there was paralysis or not the patient was treated by rest in bed for safety by the conservative surgeon, although twisting or turning in bed can be as dangerous as manipulation In still other instances, there were multiple injuries precluding any type of reduction, either closed or open, forcing a program of watchful waiting. Surprisingly enough, most of these patients recovered completely and returned to their usual work long before some of the other patients with less formidable appearing x rays but who had had a good reduction with a hyperextension body jacket from sternal notch to the pubis This was maintained continuously for six months or changed every two months as necessary for proper fit until bony union was thought to be solid. The patient was sometimes fitted with a back support after removal of cast and encouraged to rehabilitate himself The usual physical therapy and exercises were prescribed to help the patient recondition his muscles and joints It required nine months to a year for a

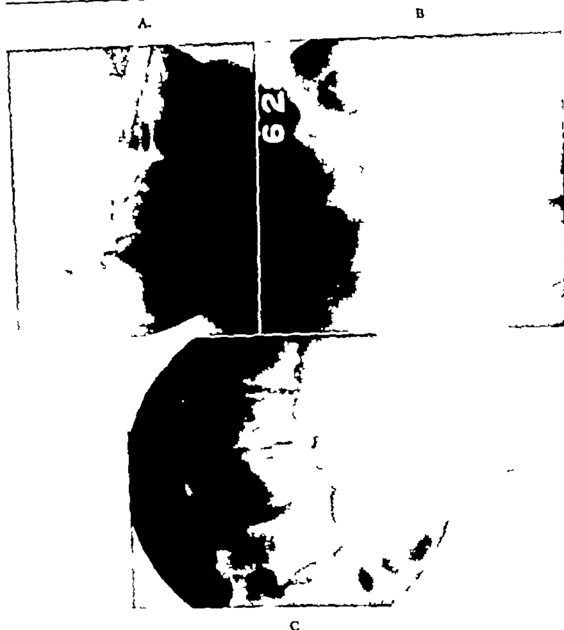


FIG. 3 (A) Compression fractures of D-12 and L 1 (B) Postural reduction with correction maintained in body cast for three months followed by hyperextension brace for two months. (C) Anterior fusion after two years. Went back to light work in one year Pain until fusion was completed.

good functional result and in some cases, he could not return to his former occupation.

It is a well-known fact that a permanent defect of varying degrees remains in all vertebral fractures Even in cases which show good reduction there is usually some narrowing of the disk space although the wedge deformity in the bone has been satisfactorily corrected and maintained until bony union is complete

There are many cases that result in spontaneous anterior or lateral fusion whether reduction has been done or not. The point of greatest pressure from de



A

Fig. 4 (A) Central body fracture with involvement at base of pedicle. Treated in bed for six weeks then Knight spinal brace followed by corset. Patient seventy years old. Recovery with slight residual pain.





B C.

Fig. 4 (B) Apparent encroachment on spinal canal. No neurological signs. Has occasional pain. (C) Bilateral fusion. Slight residual pain in spite of fusion.

formity apparently acts as a stimulus to bone growth across the intervertebral space When fusion takes place local pain disappears

From the foregoing discussion of hyperextension treatment we gather that results have been good but the patient has suffered more inconvenience and loss of time from work than in some of the so-called neglected cases There is no place for the term neglect in good surgery but we use it as a means of stressing the prevention and treatment of cord damage, more than bone injury in acute cases. However we should not lose sight of the fact that proper evaluation and care of the bone injury will prevent further cord damage. We must strive to give the best treatment within our own capabilities aiming at restoration of all patients to their original, useful position in society as quickly as possible and with the least permanent functional disability The patient s comfort must also be considered at all times during treatment.

Since the 1930 s the subject of spine injuries has been extensively studied and classified Treatment was well standardized and understood by most surgeons treating fractures of the spine However in 1949 E. A. Nicoll of Mansfield England, reported in the British number of the Journal of Bone and Joint Surgery 166 fractures and fracture-dislocations of the dorsolumbar spine occurring in miners treated by unorthodox, conservative methods based on a different concept of classification. He developed a brilliant, but controversial method of classification and treatment by dividing the cases into "stable" and "unstable" types The former were treated by ordinary graduated exercises The latter were treated in a "protective" plaster jacket in the neutral or straight position Quoting from his article will explain his theory more clearly than paraphrasing it.

"The vertebral bodies are therefore, allowed to approximate in the plaster so that anterior fusion can occur In practice, spontaneous anterior fusion with deformity gives better functional results than surgical fusion"

In respect to this last assertion one can also add spontaneous lateral fusion in lateral wedge fractures also results in a more efficient immobilization, than posterior surgical fusion. E A. Nicoll performed fifteen posterior fusions with the double "clothes-peg" graft described by Bosworth of New York, in 1942, in order to determine whether or not the long term results would be better than those obtained by spontaneous anterior fusion.

The stable types included simple anterior wedge fractures without rupture of the posterior interspinous ligaments which may cause dislocation of facets It also included lateral wedge fractures and laminar fractures above the fourth lumbar level

The unstable fractures include all fracture-subluxations with rupture of the interspinous ligament, all fracture-dislocations and all laminar fractures at the level of the fourth and fifth lumbar vertebrae

The stable type do not threaten the cord, whereas, the unstable type may threaten it by gradual forward displacement.

Mode of Injury Fractures and dislocations of the spine occur commonly in the flexible lumbar and cervical regions The incidence is low in the dorsal area because it is more rigid. The usual mechanical force which produces these injuries is one of flexion with the addition of compression or rotation forces

in certain cases Falls from a height and automobile and mining accidents are re sponsible for the majority of fractures and dislocations Airplane accidents take a great toll of lives by injury to the spine

There is considerable interest at the present time concerning the position of the seat, in relation to fatal injuries Experiments are being conducted in positioning the seats with the back toward the front of the plane so that the passenger faces the tail

Seats are being constructed to cushion the spine against violent impact It has been reported that many deaths are caused by the terrific forward whipping of head and body across the safety belt when the plane crashes Even with belly crashes of the plane there is always a forward motion besides the upward thrust which is transmitted from the pelvis or legs to the spine and even to the skull Some favorable results have been reported from changing the shape and positioning of seats but there is considerable research yet to be done before any accurate conclusions can be drawn

Hyperextension injuries are relatively rare and may occur in the cervical region following a fall on the face or blow to the forehead, whereas, in the lumbar area it may occur with violent auto accidents falls or rare athletic injuries

It is worthwhile to note that a fall on the feet from some height, may cause a fractured spine even if the foot or ankle injury is only an apparently minor sprain. Fractures of the os calcis are classical examples of this fact but ankle injuries whether minor or severe, can be associated with spine fractures also. Some patients may not have much pain at the site of fracture and if they do they may make light of it. Always take a roentgenogram of the spine after a fall from a height.

Another type of injury producing spinal fracture is a fall on the buttocks or upward thrust on the buttocks produced by the seat of an automobile when going over a bump in the road.

Lastly we must not forget the spontaneous fractures of the spine in osteoporosis and osteomalacia due to endocrine disturbances senility or disorders of calcium metabolism

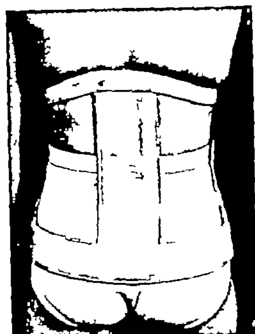
Dorsolumbar Fractures without Neurological Involvement

Except for fractures of the transverse processes these are the most frequently encountered spinal fractures in surgical practice

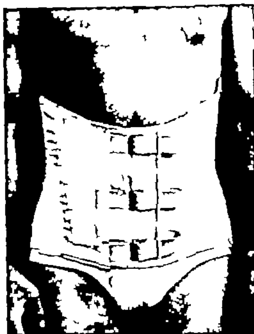
1 In minor wedging or compression of vertebral bodies and in small anterior chip fractures the patient is put to bed and made comfortable No reduction is necessary in any case, regardless of age

Treatment is symptomatic and may require very little sedation. Acute symptoms subside in a week or ten days. Abdominal distention or urinary retention disappear quickly when reflex in nature The patient is fitted with a high Knight spinal brace reaching about five segments above the fracture going higher or lower as indicated, and light activity is encouraged with mild exercise Periods of rest during the day are advised as needed

2 Moderate to severe wedging or compression of the vertebral body without involvement of neural arch without dislocation and without encroachment of bone on the cord, is best treated by one stage early closed reduction in hyperextension after a short preliminary period of observation This treatment

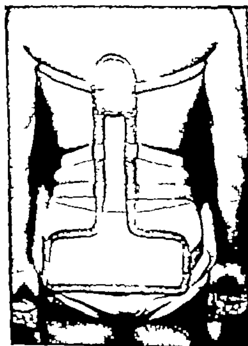


A.

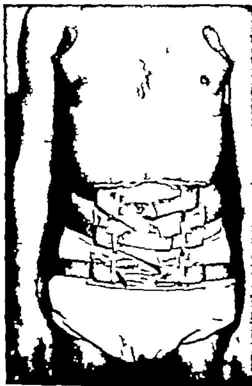


B.

FIG. 5 Knight spinal brace for dorsolumbar injuries. (A) Rear view (B) Front view



A.



B

FIG. 6. Taylor cowhorn brace for dorsal and dorsolumbar injuries. (A) Rear (B) Front.

is meant for robust individuals not for elderly people The patient is kept in bed for a day or more allowing time



Fig. 7 Anterior marginal chip fractures of lumbar three and four *Slight compression* of lumbar one. Treated with bed rest for three weeks because of chest injury then brace for two months. Full recovery

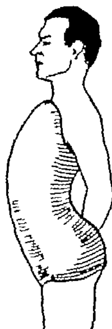


Fig. 8 Hyperextension body jacket (after Compere and Banks, Fracture Treatment)

to eliminate shock and to empty the bowels and urinary bladder Good films are studied and the patient is made ready for the plaster room. Demerol and atropine are given one-half hour before reduction The patient is taken to the plaster room and a well fitting properly padded body cast is applied from the sternal manubrium to the symphysis pubis The Watson-Jones method of suspension between two tables, and the Davis technic where the legs are suspended in the air while the chest rests on the table are the simplest methods for obtaining hyperextension and reduction by postural means In the Watson-Jones technic one needs only two tables which are padded with soft material to rest the arms and legs Body stockinette is applied first and then the patient is placed face down between the two tables The arms and chin, not the chest, rest on the table. The upper thighs rest on the other table, not the pelvis or the legs below the knees The body is allowed to sag and reduction is completed by slight pressure over the deformity with the heel of the hand Felt padding or sheet cotton held firmly with flannel bandage is used for protection of bony joints and the cast is applied tightly to take up slack of fat and padding. The patient is then turned on to a stretcher lying on a pillow under the hollow at the back of the cast. Trimming is carefully done with a sharp knife, allowing movement of the arms for personal hygiene and in both groins, for sitting in a chair He is then turned on his face with pillows under the chest and pelvis to prevent cracking of cast. Then the back is trimmed.

With the Davis method the patient is suspended in the air by the ankles which are prepared with a padded cuff and ring to which is tied a rope, run-

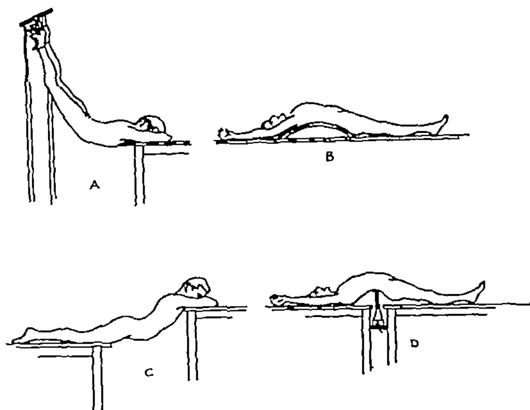


FIG. 9 Hyperextension methods for dorsolumbar fractures. (After H. E. Conwell—in Ellis the injured back and its treatment.) (A) Davis. (B) Goldthwaite bars. (C) Watson-Jones. (D) O'Donoghue automobile jack (Reyerson)

ning upwards over a pulley in the ceiling or suitable overhead frame, such as the Abbott type The arms and chin rest on a cushioned table and the spine is allowed to sag for reduction, as in the Watson-Jones technic which is actually a simplification of the Davis technic.

There are many other methods which can be used with equally good results The parallel Goldthwaite irons are set on a small portable frame. A piece of felt is laid over the irons and the patient is placed face up with the back against the irons The point of fracture is placed over the apex of the convexity of the frame. The jacket is applied around the body and irons but these are slipped out after the cast is set. This frame is useful in mid-dorsal fractures where local pressure can be exerted at the point of fracture over the spinous process This must be done manually in the postural methods.

The Reyerson automobile jack technic described by O'Donoghue in 1936 is based on the same principle Care is necessary to avoid pressure necrosis of skin even with felt padding. Very often the felt pad must be so thick that the advantage of local pressure is lost. These fine points can be ironed out if meticulous care is taken to study the technic. The platform on the jack should be specially constructed to avoid pressure necrosis of skin. A straight wooden or metal bar resting between two tables is also a good fulcrum over which a mid-dorsal spine fracture can be reduced and immobilized in plaster One person must support the head and neck and another person the legs.

It is worthwhile mentioning the spe



FIG. 10 E. L. Jewett brace for reducing and maintaining dorsolumbar fractures. (Photograph taken from advertisement in J Bone & Joint Surgery July 1952.)

cial reduction brace devised by E. L. Jewett and reported in 1950 It appears to have excellent possibilities of replacing all other methods of hyperextension reduction and immobilization It is a simple light, waterproof efficient brace which has proven satisfactory in the designer s hands and will probably find more enthusiasts as time goes on It embodies the three point pressure principle and is similar to the Baker hyper extension brace for kyphosis The above author has reported good anatomical reduction of wedge fractures in adult age groups

In elderly people, no plaster is used because they are extremely uncomfortable Severe fractures are treated by rest in bed with hyperextension only as tolerated by the patient, with a pillow under the mattress or a Gatch modification of the regular hospital bed. They are made as comfortable as possible and walking is allowed with a brace as soon as the bony deformity permits Where there is instability of the fracture, bed rest is continued for six to eight weeks A Knight spinal or hyperextension brace is used as soon as symptoms and x ray examination will allow Some stability must be present for weight bearing.

It is sometimes impossible to evaluate the degree of damage to the posterior elements and in some cases, one can certainly upset a delicately balanced fracture-dislocation by any kind of one stage manipulation so that a relatively good functional result will be converted into a tragic paralytic case

Gradual hyperextension in the supine position, using any type of frame or bed, may be satisfactory for varying periods of time, but the degree of extension necessary for complete reduction is not tolerated by most patients, thus leading us to the use of lesser degrees of hyperextension sufficient to give some distraction of fragments, which in turn, will relieve pressure by changing the shape of the bony and ligamentous envelope surrounding the cord and nerve roots In certain cases, the use of complete hyperextension can be dangerous without absolutely accurate knowledge concerning the integrity of the posterior elements Stretching of this envelope made up of combined rigid and elastic elements which are in some state of disorganization, will cause rearrangement of some of these elements, but not positive anatomical reposition. Moreover none of these cases with severe wedging or compression whether anterior or lateral, escapes some degree of residual traumatic arthritis or painful deformity unless complete bridging with fusion takes place

We all know that fusion occurs just as readily or even more readily in unreduced fractures as well as in those



A.



B

FIG. 11 Hyperextension in bed. (A) Gatch method. (B) Blanket roll under mattress.

which are corrected. Both anterior and lateral fusion occurs spontaneously in many unreduced fractures. However it can be said that a case which has been reduced may heal almost normally with intact disk space no fusion, and no cosmetic defect, but this is rare and some people do not care about a slight amount of kyphosis if they can be comfortable and more quickly returned to their jobs

Reduction by hyperextension is sometimes desirable if the patient tolerates it. It is desirable in active people if a near perfect result can be anticipated. Remember that a fat person is difficult to hold in hyperextension in a cast. In severe fractures and dislocations it is necessary to have flawless x-ray films and expert interpretation of findings There should be excluded the danger of jamming broken pieces of posterior elements into the cord. Look out for posterior body fractures where the posterior border has spread backwards in the neural canal and may compress the cord, rather than pull away from it as the spine is hyperextended. Hyperextension fractures with bursting open of the body and rupture of the longitudinal ligaments are not to be hyperextended

Fractures of Upper Dorsal Vertebrae- These injuries are treated much the same as cervical spine fractures except that skull traction is not usually necessary Hyperextension is uncomfortable and full correction of bony deformity cannot be maintained. Local pressure is necessary for reduction and this can be obtained with Goldthwaite irons or automobile jack. The head and neck are included in the plaster Calot jacket. The most rational treatment seems to be partial closed reduction without attempting complete correction of deformity A plaster Calot jacket is applied in severe fracture-dislocations without paraplegia and a combined spinal and cervical brace is used for less severe cases Mild cases are treated by rest in bed for a few days and protective splinting as necessary Early spine fusion is to be considered for unstable fractures

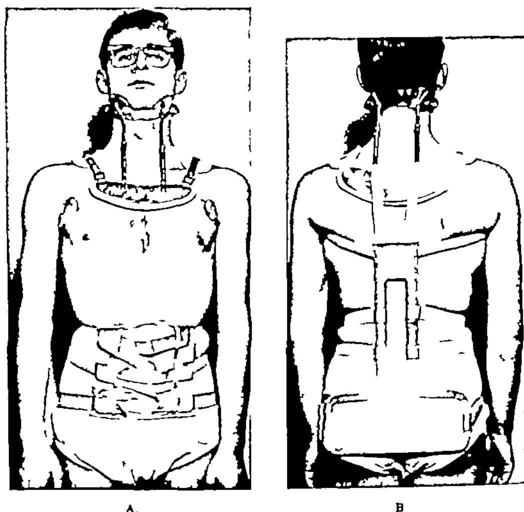
Paraplegia is best treated by rest in bed until the patient is ready for wheel chair or crutches The prognosis is worse in cord injury of the upper dorsal than lower dorsal spine because there is less room for movement or expansion of the

cord. Many cases of paraplegia clear up with good results if treatment has been adequate

TRAUMATIC SPONDYLOLISTHESIS

This is a rare injury and implies some degree of slipping forward of the fifth lumbar vertebra on the sacrum If there is slipping backward it is called reversed spondylolisthesis If the defects or fractures are present but no slipping has occurred it is known as prespondylolisthesis This condition may involve the fourth or third segments in that order of frequency The vertebra does not slip singly It moves forward with the rest of the vertebral column above it.

Spondylolisthesis or any of its variations does not occur with minor injuries. A violent sheering force is necessary such as may occur in auto accidents, mining accidents or falls from considerable height The commoner form of this deformity is usually considered a congenital defect which may be first noticed at some period in adulthood. Symptoms may occur as early as adolescence, but not as a rule Slipping occurs to the



A. B

FIG. 1. Cervicodorsal brace for high dorsal fractures or severe cervical injuries. (A) Front view (B) Rear view

age of bony maturity but stops after that period is reached Spinal bony maturity can be determined by the appearance of fully developed or ossified iliac apophyses. Although it is considered a congenital defect by most authorities there are some who suggest the possibility of hyperextension injury at birth when the child is suddenly suspended in the air by his feet after having rested in the uterus for nine months in a position of universal flexion of the spine Moreover constant movements of the lumbosacral region during infancy when cartilage centers are soft, may cause fractures without obvious symptoms.

The defect is found in the articular processes laminae, or pedicles In order to allow slipping the defect must be bilateral. Treatment of a purely traumatic lesion consists of rest in bed with the thighs flexed close to the abdomen and suspended in the air

One-stage closed reduction can be done by this maneuver followed by application of bilateral plaster spica while the thighs are suspended at an angle of ninety degrees with the trunk. The spica extends from chest to the knees If displacement is severe with considerable angulation deformity at the lumbosacral junction or protrusion of the vertebral body into the pelvis and if symptoms become worse instead of better one must do a posterior spine fusion.

Progressive displacement with unequivocal proof of its occurrence whether traumatic or congenital also requires spine fusion. Open reduction can be tried in the prone position by pulling on the spinous process with a bone forceps The fusion includes one vertebra above and one below the slipped one The double clothespin graft of Bosworth or (H) graft of Moore are highly efficient procedures in obtaining prompt fusion Multiple chips are packed around the grafts to promote osteogenesis

In previous years there was a fifty per cent failure following spine fusion for spondylolisthesis. Now it is somewhat less with use of these new graft technics, using cancellous bone from the iliac crest.

Fractures of Transverse Processes

This injury is not serious, as a rule Considerable soft tissue damage may occur if more than one process is fractured and displaced any considerable amount. A hematoma forms in the psoas and quadratus lumborum muscles causing pressure on the surrounding structures which include the ureter genitofemoral



Fig. 13 Fracture of all five lumbar transverse spinous processes. Urinary retention. No other complications. Bed rest three weeks for pain. Knight spinal brace three weeks. Working as secretary at eight weeks. Fell off horse.

nerve, part of the lumbosacral plexus, and the lumbar arteries and veins.

Fracture of a single process with no displacement is usually due to a direct blow Separation may mean avulsion and direct injury combined. Minor injuries are treated symptomatically and, as a rule, remain ambulatory The back is strapped with adhesive in a basket weave pattern held with a few horizontal strips

Multiple fractures of these processes require bed rest and catheterization for study of urine or retention. Sedation is prescribed, as necessary It may be necessary to do a pyelogram to rule out injury to ureter Acute symptoms subside in about a week or ten days when the patient is allowed up with a Knight spinal or Taylor brace to support the torn muscles Mild exercises are prescribed after the third week to recondition the muscles.

It is rarely necessary to operate on these fractures even if fibrous union is obtained.

Fractures of the Laminae

This may be due to a direct blow to the spinous processes or to a hyperextension injury of the spine crushing the lamina against the spinal cord or nerve roots. Clear x-ray films are necessary to see this fracture and if there are signs of paralysis with spinal block, and no apparent fractures on the x ray film, one must suspect this fracture. If spinal block with no evidence of improvement in the neurological state is noted open reduction with laminectomy should be done

The patient is kept in bed for six weeks and then allowed up with brace or plaster jacket. Immobilization is continued for six to eight weeks longer depending on symptoms of pain or weakness in the back and legs

Fractures of the Spinous Processes

These fractures are rare in the dorsolumbar spine The photograph in the section on Fractures of the Pelvis showing such a fracture involving the fifth lumbar vertebra is probably a "Chance" fracture described by G Q Chance of England as a laminar fracture which splits the spinous process down the middle then runs through both laminae also through both pedicles and ends up in the body of the vertebra It is described as a flexion fracture which may compress the body anteriorly while opening it posteriorly if the force is great enough. Better films could not be obtained to demonstrate this point, but another feature described in this type of fracture is also noted in this photograph that is a fracture of the transverse process. There is a subluxation of the right lumbosacral joint and a fracture of the sacrum through the upper part of the sacroiliac joint This nineteen year old girl had a partial paraplegia with bladder and bowel disturbances She had bladder stones which were removed and also an appendectomy was done After bed rest for two months she was allowed up with a McAusland brace and taught to walk in a walker The patient left the hospital three months after the injury without assistance and is now well These fractures are usually seen in the cervical spine and are described elsewhere

Disk Injuries

The intervertebral disk is injured frequently in all fractures of the spine and often with minor sprains if there are degenerative changes which have weak

ened its structure either from previous injury arthritic processes or many years of hard labor

Acute symptoms following any injury may be transient and disappear for varying periods of time. The weakness may remain dormant for many years, especially in the cervical spine where daily requirements of stress are not as great as in the lumbar region. Traumatic arthritic change may become well advanced, sometimes making it difficult to differentiate between localized osteoarthritis and traumatic arthritis

As a rule osteoarthritis in any region of the entire spine is distributed evenly throughout whether it is purely degenerative or partly rheumatoid

Localized arthritis is usually due to abnormal pressure forces following injury old deformity or less commonly following infection. Treatment in the cervical region consists of prolonged, conservative management when paralysis is not present and root pressure symptoms can be relieved without operation.

A short period of continuous traction with a halter in recumbency rather than intermittent traction in the erect posture is more effective Three pounds of weight are used for continuous treatment in bed, or the weight of the trunk up to 20 3 kg (50 pounds) can be used for several minutes while the patient sits in a chair in the intermittent method.

A plaster collar or cervical brace of Forrester or Thomas types, are used as long as possible when patient is out of bed. This type of support can be used *indefinitely* as long as there is improvement. Antiarthritic remedies are *quite* helpful in many cases and should be tried. Regulation of weight and general body health is important in some cases Increased weight and nervous reactions tend to aggravate subjective symptoms by increasing intraspinal pressure X ray therapy helps in some cases and may help to resolve edema or abnormal local calcium metabolism. If symptoms of root pressure increase instead of subsiding, one must consider laminectomy The symptoms are characterized by pains about the head and neck or occipital neuralgia, radiating down the arms numbness and tingling in the hands, atrophy or weakness of intrinsic muscles of the hand, paresthesias of the face, difficulty in swallowing, and pains or weakness in the legs, which should be differentiated from generalized arthritis.

Herniation of a lower lumbar disk may also give late symptoms of nerve root pressure. Conservative management is also important, but operation is not as formidable as cervical laminectomy and should not be unnecessarily withheld if there is persistent disability Negative spinal tap and negative myelograms do not contraindicate laminectomy with or without spine fusion. It is mechanically unsound to remove a disk without spine fusion. Removal of all disk material is not accomplished at laminectomy and recurrence of pain is common.

Each *individual* case poses its own problem and the question of spine fusion should be studied thoroughly in all cases of herniated disk. If instability is likely to cause pain after operation, it is best to fuse the spine, including two vertebra above and one below the space, with lumbosacral or disks. The patient is kept in bed three weeks with an abdominal binder and turned at frequent intervals postoperatively

He is allowed out of bed with a

Knight spinal brace or plaster cast after three weeks Physical therapy is started at four or five weeks and light work is resumed in two to three months The patient should be rehabilitated in four to six months depending on type of occupation

Treatment of Paraplegia

The results of open reduction or laminectomy are disappointing in paraplegia, whether complete or partial. The operation should be postponed for one or two weeks in the cervical spine In the dorsal spine it may be done during the first week if the condition of the patient permits The lumbar spine and caudaequina are more amenable to surgery because the patient is in better general condition the nerves are easily handled and rearranged they have the power of regeneration and above all, there is more space for the nerves to accommodate themselves, making it less dangerous to move the patient or to perform local surgery on the bone or cauda equina

Hemilaminectomy is the procedure of choice in the cervical spine complete laminectomy in the dorsal or lumbar spine and in certain cases open reduction or facetectomy in the lumbar spine Some men do not allow open reduction anywhere in the spine when there is cord damage They prefer laminectomy because they feel that decompression is the prime consideration with inspection of the neural canal Once laminectomy is to be done for this purpose other bone manipulation whether before or after could be dangerous

The indications for early surgery are few and have already been discussed elsewhere in this chapter The management of bony deformity has been outlined but bears brief review

Skull traction in cervical cases is the most efficient. Some cases with replacement dislocations or fractures in good position, can be kept in light halter traction or held in neutral position of extension with sandbags and pillows In high dorsal fractures the head and neck are similarly held in the neutral position and where necessary skull traction is applied to obtain a pulling effect in this location

Because of the devastating effects of pressure sores from casts or decubitus there is considerable difference of opinion concerning the use of plaster casts or half-shells of any kind, in patients with partial or complete paraplegia In cervical cord injuries deaths have been reported from interference with respiration and from sneezing where the fracture is highly unstable Highly competent authorities in the fields of orthopedics and neurosurgery take opposing views in respect to this phase of treatment It is probable that these men have specific types of cases in mind because both viewpoints are understandable Many of us are aware of the lightning-like manner in which pressure sores develop in a severe case of paraplegia. On the other hand, we have also seen gratifying results in mild paraplegia where plaster shells or even casts have been used Meticulous attention to detail and diligent nursing care are responsible for this success Sometimes it may be pure, blind luck.

The most important thing to remember is that treatment should be aimed at both spinal cord and vertebral column. We must not give up protection of the bone injury even in an apparently hopeless transection Plaster dressings half-shells and casts are better avoided entirely when there is cord damage The spine can be protected in bed by fol-

lowing certain rules which have been previously stated. Once a patient is in bed he cannot be turned on his abdomen safely Tilting just a few degrees on one side or another and propping with pillows every two or three hours, to take care of the back, is permitted.

Five persons are needed for cervical spine cases One for the head and four to control the body and legs. In dorsolumbar cases three or four may be sufficient. If the patient is turned fully on his side the blanket roll under the mattress or the angle in the hyperextension bed must be flattened out in dorsolumbar cases to prevent lateral angulation of the spine

In some cases no extension is needed and the spine can be nursed on a flat bed, always remembering not to flex it at any cost. In certain types of bony injuries it is often sufficient to give hyperextension for several hours in order to obtain whatever correction is thought necessary and then reduce this hyperextension to the point which is compatible with safety for the injured structures and comfort for the patient.

In many instances the angulation can be lowered to the straight or slightly extended position. The Stryker frame bed is sometimes convenient in these cases, but it is too narrow for general use and the patient must be nursed in the flat position.

Skeletal traction to the lower extremities is rarely indicated and adhesive tape or any other type of skin traction should never be used in the presence of cord damage

Holdsworth of England and several other authors advocate early internal fixation by bolting a plate to the spinous processes in unstable fracture-dislocations of the dorsolumbar spine. It is found that this type of fixation will give the desired amount of immobilization during the first four weeks when the danger of displacement is most likely to be present. Other men suggest the addition of bone grafting to this procedure because metallic fixation works loose after a few weeks because of aseptic necrosis Plaster casts are not used. Each case can be decided on its individual merits

The chief concern is protection of the cord and skin. Alcohol, tincture of benzoin spirits of camphor and talcum powder are useful agents to keep the skin firm. Gentle kneading with the finger tips will improve circulation of tissue fluids A rubber foam or soft air mattress is the best bedding to use Extreme care must be exercised in removing the bed pan because the skin may stick to the pan and peel off the buttocks as it is removed. All creases in linen should be straightened out and the mattress should be covered with rubber sheeting A draw sheet under the patient will facilitate turning and lifting. Moist or soiled linen should be changed promptly Pillows are used under the thighs knees, and legs to raise the heels off the mattress and avoid pressure The knees are semiflexed and the ankles are held in the neutral dorsiflexed position. All joints in the entire upper and lower extremities must be moved through their normal range frequently A physical therapist will help keep the patient physically and mentally fit right from the start. The patient must be encouraged by everyone in attendance to aid in recovery

In cervical lesions one must watch out for pneumonia because of paralysis of chest muscles leading to poor respiration. The diaphragm alone is not sufficient for proper expansion of the lungs. Oxygen must be ready at all times and



FIG. 14 Complete transection. Fracture-dislocation cervicodorsal spine. Died within a few hours. Note fractured ribs on both sides.

given as needed The Drinker respirator is often life-saving

Dorsal spine injuries are often associated with fractured ribs pneumothorax, and hemathorax Tension pneumothorax requires prompt relief Difficulty in breathing comes from many other causes besides pneumonia and the above conditions are among the major ones Abdominal and bladder distension will also embarass respiration These latter symptoms plus the tendency to pressure sores and priapism are more profound in caudaequina lesions

Antibiotics of all types must be used because of resistant organisms, especially those of the genitourinary tract. A Levine tube is passed if the patient cannot swallow or if abdominal distension from paralytic ileus and cord bladder lead to vomiting Retention of urine is a difficult problem and requires the attention of a urologist. Most deaths are due to urinary infection with uremia



FIG. 15 (A) Comminuted fracture of cervical five and six. Severe quadruplegia. Pneumonia, cord bladder and sepsis. Treated with pillows and sandbags around neck. Bladder irrigations. Good recovery with brace for neck and both legs. Neck brace removed at four months. (B) Beginning anterior fusion.

or pneumonia Bladder stones are common and are mainly due to infection

One catheterization may lead to serious infection. On the other hand, attempting to establish an automatic bladder by distension and overflow is uncomfortable and may lead to frequent bed wetting which is bad for the skin It may also cause abdominal distension and vomiting. Manual expression requires a special nurse who is experienced in these cases so that the bladder is emptied every six hours before it becomes fully distended. Repeated catheterizations denude the mucous membrane of the urethra and start a local infection which is pushed into the bladder each time the catheter is passed

An indwelling catheter leaves residual urine which becomes infected and requires frequent irrigation with ten per cent argyrol until tidal drainage or cystotomy is done The most practical system for the average hospital case with paraplegia is tidal drainage

Fecal impactions often cause serious abdominal distress and must be relieved by frequent retention enemas with mineral oil and digital manipulation when necessary For evacuation and cleansing, irrigations are more efficient than simple enemas alone A rectal tube should be used almost constantly but must be removed periodically to prevent local injury to anal mucosa.

Acute abdominal emergencies require considerable judgment in their management. This type of surgery cannot be done when there is paralytic ileus spinal shock, or surgical shock.

In dorsal cord lesions or transection the patient empties the bladder by reflex but he cannot control it and is always in fear of bed wetting. In caudaequina lesions voluntary control is established but the stream must be forced by straining after the bladder is full There is no reflex emptying.

After several weeks the tendency to bed sores and bladder infection subsides The vascular trophic disturbances improve with time Better tone of blood vessels is established The improvement is more rapid in caudaequina lesions than in dorsal or cervical areas Dorsal injuries are the worst.

It is clearly shown that acute traumatic paraplegia is best treated by close teamwork among many people connected with the hospital, from the orderly to the superintendent. Physical therapists nurses, internes residents and attending physicians in all fields of medicine and surgery must work as a unit to help this type of case

Treatment of Compound Fractures of the Spine

The general supportive treatment is the same as in compound injuries of the extremities but local surgical treatment is of secondary importance to the evaluation of any possible cord damage Shock and hemorrhage are controlled, tetanus and gas bacillus antitoxin must be given Antibiotics are started routinely to prevent infection. The wound is not treated until cord injury has been evaluated and x rays taken to determine exact status of bony deformity and location of foreign bodies in case of penetrating injuries Above all, one must remember to avoid injury to the cord or meninges during debridement of other soft tissues or bone The cord nerve roots and peripheral nerves are never debrided or injured in any way There should be no prying or forcible manipulation of bony fragments No large bone fragments are removed Deeply embedded foreign bodies in bone are not removed if any force is required. If fragments are to be loosened or small spicules are to be removed, they should be cut away from their attachments by cutting with knife or scissors Any hemorrhage in the wound is aspirated with suction apparatus Lacerated nerves are sutured

The dura is not opened except for decompression of cord or evacuation of blood from subdural area. It is left open and the edges are packed with gelfoam to prevent a fistula If it is found lacerated it may be closed Penicillin streptomycin and sulfanilamide are applied to the cord and all about the wound No open reduction or laminectomy is attempted unless the indications have been studied as outlined under those headings

The wound is closed without drainage if possible. Sutures are preferably of silk and used sparingly If drains are needed use them superficially and remove them in forty-eight to seventy two hours

Open Reductions

This operation is not an emergency procedure. If there are no neurological signs there is doubt as to whether it is ever indicated in dorsolumbar fractures or dislocations When open reduction is done, it should be combined with posterior spine fusion by bone grafting to insure stability of spine The trunk is kept in the neutral position without extension and support can be given with a brace or body cast. Spontaneous anterior fusion is aided by avoiding hyperextension

Open reduction is a dangerous and formidable procedure in the cervical spine and should be done under optimum conditions of teamwork and with proper equipment. Skull traction is necessary in unstable injuries during operation and is continued without interruption postoperatively Weights are then reduced to five pounds The neck is kept straight and any pressure on the chest is avoided to allow free movement of the diaphragm during respiration. Exposure is made by midline incision and subperiosteal dissection from above and below the injured vertebra working towards it and carefully preserving the interspinous ligaments for stability The spinous processes are wired together pulling a dislocated segment down towards the normal one, and in case of fracture, the involved vertebra is pulled up towards the intact spinous process

If there is comminution of the neural arch the next intact spinous process is included in the fixation Two or three segments are sufficient for stability Wiring must be followed by iliac crest bone grafting to insure permanent stability Wiring alone will not prevent recurrence of deformity after the patient is ambulatory without external fixation with a brace or cast. In some cases, even casts and braces cannot prevent dislocation and death during bouts of coughing or sneezing

When the atlas or axis is involved, it is often necessary to wire the spinous processes to the skull and fuse them to the occipital bone by iliac crest graft. The ligamentum nuchae should be handled carefully and repaired well to preserve stability in traction.

Open reduction in the presence of paralysis is dangerous and is done only as part of a decompressive laminectomy if at all. A simple facetectomy as described by Watson-Jones may improve the bony deformity sufficiently requiring less extensive surgery to relieve spinal block. In some cases of intractable root pain caused by pressure from a bone fragment or spicule open reduction may help Decompressive laminectomy is the procedure of choice when surgical intervention is necessary for relief of increasing paralysis or persistent spinal block with stationary signs, indicating a possible epidural hematoma, subdural hemorrhage or hematomyelia. Apparent bony encroachment is not in itself an indication for surgery Cauda equina lesions respond more favorably to surgery because the peripheral nerves regenerate The cord does not.

Dorsal spine lesions have the worst prognosis because the cord is more closely confined in a more rigid tube allowing only a small margin of safety with any displacement. There is usually less improvement in any injury of the dorsal cord than in cervical or lumbar areas Laminectomy for complete paralysis or transection of the cord is useless Open reduction or laminectomy is rarely indicated in any spine injury and should not be attempted unless the indications are clearly defined.

Decompressive Laminectomy

Because there is paralysis, sensation is depressed and operation can be done under local anesthesia in dorsolumbar fractures The incision is made in the midline at the level of sensory change extending a few segments above and below this level. Subperiosteal dissection is carried out along normal vertebrae above and below the injured one, working towards it by sharp dissection to avoid rough stripping, manipulation and pulling of the loose fragments The intact vertebrae above and below the in-

jured one are unroofed completely re moving the entire spinous processes and all the laminae Attention is then focused at the level of injury removing this neural arch last. The dura is then opened and the cord is inspected The presence of pulsation above the injury and non b low indicates spinal block Dentate ligaments on each side of the cord are cut and used as retractors to rotate the cord Loose spicules of bone or disk tissue are lifted out without force of any kind

A thin rubber catheter is used to probe the canal above and below the level of injury in search of obstruction Needle aspiration of cord can be done for hemorrhage but only a cystic cavity associated with syringomyelia may be opened and sutured around the edges to prevent recurrent accumulation of blood.

Bony deformity is not corrected if any force is required or if there is danger of sudden displacement with injury to the cord Electrical stimulation is done on the anterior horns of the cord to determine whether or not impulses are getting through the level of injury to the extremities The muscles will jerk if the paralysis is not complete The wound is then closed leaving the dura open for decompression. This opening is packed with gelfoam to prevent fistula formation with leakage of spinal fluid Sulfanilamide penicillin and streptomycin are applied locally and closure is completed, using silk and without drainage.

In the cervical spine a hemilaminec tomy technic is used, avoiding any injury to the interspinous ligaments After the normal laminae above and below the injured one have been removed the procedure is carried to the lamina at the point of injury The dura is opened and all the other details are followed as in dorsolumbar laminectomy If more ex posure is needed, the bone is removed from the base of the spinous process working towards the midline If the other side needs exposure, the procedure is repeated, always remembering to work from intact bone to point of injury

Closure is done by same technic as in dorsolumbar area

Postoperatively light skull traction is continued until a plaster jacket or brace can be applied This requires six to eight weeks

Spine fusion should be done before removing the cast or brace permanently in all cases that have had a total de compressive laminectomy When more than one lamina is removed there is always some instability which is best treated by bone grafting More bone than is realized is usually removed at these operations and the spine is often left without support

Spine Fusion

When this procedure is done to stabilize injured vertebrae it involves fixation of one segment above and one below in the dorsolumbar regions includ ing three vertebrae in the fusion In the cervical spine it is usually sufficient to bridge two vertebrae but others can be added as indicated in each individ ual case However to bridge defects after decompressive laminectomy it may be necessary to bridge up to six or eight segments A tibial bone graft is necessary for wide open defects of great length

The incision is made directly in the midline to avoid bleeding and is carried down to the bone at the tips of the spinous processes The fascial and liga mentous attachments are cut close to the bone with a knife making it easy

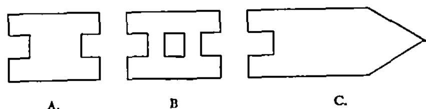


Fig. 16. Self-locking bone grafts. (A) Bosworth clothespin. (B) Moore (H) graft. (C) Modified clothespin for occipitocervical fusion.

to start subperiosteal stripping by insertion of a sharp chisel or sharp elevator of the Hibbs type under the periosteum just below the overlapping edge of the tip of the spinous process Blunt elevators are useless and traumatizing They slip away from the bone and leave torn ends of soft tissue still attached to the bone. If fusion is to be obtained, all bone should be denuded of soft tissues The tips of the spinous processes with the soft tissues attached, are excised with rougeurs leaving raw bone The interspinous ligaments must be removed with a knife and the edge of the spinous processes are shaved down with an osteotome to remove all soft tissue and leave a raw surface

The laminae are then cleared of soft tissue using Cobbs spoons which are perfectly suited for this procedure They are giant curets with a long handle for leverage The cortex is then raised from the base of the spinous processes with a Hibbs gouge which is angulated for this purpose The articular facets can be destroyed by cutting the surfaces with a sharp osteotome and removing the cartilage with a small curet. The bed is now ready for bone grafting except for shaping of the spinous processes to receive either the double clothespin graft of Bosworth, or H graft of Moore

In both cases, a notch is cut with a rougeur near the base of each spinous process above and below the unstable one The notches face each other and will receive the notch at each end of the graft which is laid down flat and locked at both ends by means of these notches In the Bosworth technic the spinous process of the unstable vertebra is cut off at its base and used for chips

In the Moore technic, a square hole is cut in the middle of the graft and this is threaded over the unstable process which has been previously shaped to receive it. A round hole is easier to make and prevents fracturing the graft which is one of the advantages of the other technic Bone chips are then packed around the graft and the wound is closed in layers using chromic catgut for the deep fascia and silk for the skin. The graft is taken from the posterior one third of the iliac crest, making the incision parallel to the spine in order to avoid weakening of lumbar and gluteal fascial attachments to iliac crest. Painful fibrositis often develops at this point and must be injected with novocain repeatedly for relief

If greater exposure is needed to obtain more bone, a curved incision along the crest must be made If many segments in the cervical spine must be bridged it is sometimes necessary to take an Albee-type of graft from the tibia for greater stability in cases where extensive total laminectomy has been done The graft is then shaped as desired.

It is sometimes necessary to sink the

tip in the outer table of the skull and lock the lower end into a spinous process by the clothespin method This will stabilize the skull and atlas on the axis and lower cervical segments

Birth Injuries of Spine

Treatment of spine injuries in new born infants is fairly simple unless there is paraplegia. It is then a difficult problem to prevent decubitus sores because of irritation of the skin from excretions The bone is soft and elastic. The injury is usually of the traction type and often involves the cervical spine or brachial roots No flexion or extension forces are exerted except for lifting of the infant by the feet, which causes sudden extension of the spine after being in flexion inside the uterus for nine months This may cause spondylolisthesis

None of the injuries is severe and cord damage is not common. However there may be signs of hematomyelia with paraplegia. Severe types are usually associated with multiple injuries in still born infants Complicated dressings cannot be maintained on a newborn baby because they will wiggle out of anything and often strangle themselves or one of the extremities Firm pillow splints and sandbags are sufficient. The infant should be handled with extreme care and special attention is given to the skin Healing is rapid, but residual paralysis should be treated by frequent passive exercises of involved joints. Contractures are prevented by splinting and passive manipulations

Diagnosis of Fresh versus Old Fractures

It is sometimes difficult to differentiate between old wedge deformity and a fresh compression fracture. The history of recent injury with sharply localized clinical signs, such as tenderness over two or three spinous processes and referred pain at nerve root level radiating downwards, may be significant signs X rays may show a line of fracture or some sharp edges with interruption of continuity of some bony trabeculae

Sometimes there is more than one vertebra involved and if the fracture is old, no abnormality of bony texture is noted in the one which is less deformed. Only a minor alteration in the outline may be seen in the vertebra which is injured the least. The one which took the brunt of the injury may show spurring, changes in density and bridging defects in various stages of development several months or years after the accident. When osteoporosis is present it will be difficult to differentiate between old and new fractures if there is gradual compression of one or more vertebrae

A good test if indicated, is the test of reduction by hyperextension If the deformity is corrected it is a fresh fracture. This test is not always desirable especially in senility generalized osteoporosis or other debilitating conditions.

Another test is periodic check up of *healing process by x rays One may* often see gradual obliteration of a fracture line in a fresh fracture This may be followed by spurring, bridging, gradual narrowing of intervertebral spaces, or further compression of body Finally there may be spontaneous anterior or lateral bony fusion between the fractured vertebra and the one above it.

Injury to an old spur is sometimes difficult to differentiate from incomplete or irregular bridging defects with spotty calcifications Old epiphyseal defects at *the time of ossification in adolescence* may appear as chip fractures at the anterior margins of the vertebral bodies

The accessory centers of defects have smooth rounded edges and their texture is uniform Sometimes the surface which faces the body appears to have broken off and has the same dimensions with the same outline as the defect in the corner of the body However the edges may be sclerotic and smooth rather than hazy in outline and irregular like a fracture There may be spurring and lipping about the fragment and vertebral body in an old lesion.

Backache & Sciatica

The commonest predisposing cause to backache is rheumatism This term is used because it covers nontraumatic, painful afflictions of muscles ligaments, fascial coverings, nerves periosteum, and just plain, subcutaneous fat, as well as arthritis of the lumbosacral and sacroiliac joints

Arthritis denotes inflammation of joints and the term may be misleading if the other tissues are involved by rheumatic inflammatory processes while the joints remain perfectly free of irritation. We may call this rheumatism of the soft tissues, but not arthritis It is probably an infectious process of a toxic nature

Trauma plays a leading role in back pain because of two main reasons (1) the lumbosacral joint is subjected to great strain on account of its anatomical location (2) because it is constantly under strain during the entire day whether a person is standing or sitting. Even when lying in bed it is difficult to obtain complete rest and relaxation of the lumbosacral spine unless the bed is shaped to the body and held firm by a mattress of proper consistency

An active person who works all day in comfort and sleeps well during the night, only to awaken with a stiff back or stiff neck, is suffering from rheumatism plus back strain not just back strain.

We will not neglect our enemy the intervertebral disk at this point, but we will surely bring out the fact that its structure is not immune to inflammatory diseases It is susceptible to inflammation either directly or through secondary involvement from the surrounding ligaments, periosteum, bone or circulation Trauma will cause it to weaken further bulge or rupture through the posterior longitudinal ligament, thus initiating sciatic symptoms once it presses on the nerve root.

It is important to know that backache without sciatica occurs with disease or derangements of the disk. Sciatica comes on with nerve root pressure if an intervertebral disk is the causative agent. Very often the back pain decreases as the sciatic pain appears. Caudaequina tumor must be considered.

Arthritis of the sacroiliac joints is often present for many years without symptoms However one may have symptoms of arthritis of these joints long before there is x ray evidence of this condition. There are patients who have far advanced arthritic changes in the sacroiliac joints and who go without appreciable pain for many years This phenomenon poses a problem in differential diagnosis especially in early Marie-Strumpell arthritis

Our emphasis on rheumatism is intended to focus attention on this enigma whenever a backache becomes persistent and puzzling after proper treatment has been given with insufficient relief. Fibrositis and subcutaneous fatty disturbances also cause backache

Congenital abnormalities of the lumbosacral joints are a common cause of

recurring backache but disability varies in different individuals Heavy laborers are susceptible to frequent attacks and may be forced to change their occupa tion

The type of abnormality is important. Spondylolisthesis is the most disabling and does not stand up under heavy laboring conditions. However the presence of arthritis in damp climates makes matters worse

It is also a fact that ligaments have a poor blood supply and may be susceptible to inflammatory reactions for a long time following a healed injury without apparent cause

In cold, damp climates rheumatic disease is a predisposing factor and mechanical derangement acts as the inciting cause of backache. In other words, trauma or instability however trivial, will always initiate the pain even while moving about in bed, but there is usually some underlying inflammatory process which sensitizes the tissues in a majority of cases

Mental strain whether it precedes back pain or is caused by the circum stances surrounding a backache usually aggravates symptoms in certain unex plained ways It is possible that anxiety states cause a reflex increase in muscle tone, which increases muscle spasm to the point where the injured area is actually affected directly On the other hand it is possible to increase the intra spinal-fluid pressure by a general in crease in the tone of the body musculature thus making the nervous system more irritable and sensitive to painful stimuli This latter observation has been known for a hundred years, in the treatment of acute neurological disor ders, such as meningitis, tetanus, tox emia of pregnancy and other convul sive states It has been known for many years that a family argument will often initiate a severe attack of sciatica both in men and women who have some emotional trouble A vicious cycle can be produced by the above processes

Symptoms: The salient features of back injury are

1 Limitation of one or more spinal motions
2 Some pain with at least one movement of spine.
3 Spasm of muscles beyond nor mal tensions during movement or standing.
4 Listing or curvature of vertebral column (in standing position as opposed to normal alignment in prone position on table. To be differentiated from old deformity in childhood)
5 Local point of tenderness over involved area The deeper the injury the less response will be obtained from digital pressure unless a posterior sensory nerve passes close by and refers pain to the skin
6 Spasm of hamstring muscles, tested by raising leg in straight position Indicates lumbosacral or sacroiliac involvement. Sac roiliac joint involvement rare except for tears of sacrospinalis and gluteal muscles at their at tachments to ligaments (Dif ferentiate from congenitally short hamstring muscles by per sistence of limitation of straight less raising test, even when pain is absent, during later phases of treatment.)
7 Test for atrophy or shortening of lower extremities to rule out old condition at time of injury
8 Test sensation, knee and ankle

jerks, muscle power and gait, to rule out neurological disturbance

9 Steindler's novocain test Inject 5 to 10 cc. of procaine into spot and determine result.

10 If all tests are negative but patient has some pain at night or after resting, there is probably some element of infection or so-called rheumatism associated with injury

11 Rectal examination.

Treatment. A neglected backache will eventually require rest in bed, so the first consideration is elimination or reduction of straining influences which means partial or complete curtailment of daily activities The degree of rest depends on the symptoms and signs. If subjective pain is severe and there is only slight restriction of motion and only slight spasm of muscles, we must still insist on bed rest, because the patient is uncomfortable and will become worse without some rest.

Similarly if pain is only slight, but there is considerable restriction of motion with spasm of back muscles bed rest is also necessary in order to relieve the muscles of their self-appointed task of protecting the spine from strain or movement while the patient is out of bed. Sitting in a chair may be even worse than standing, if the flexed position causes further pulling on the irritated muscles or ligaments

In the absence of a major neurological lesion, such as a massive protrusion of intervertebral disk, bleeding into cord tumor or pathological fracture, the treatment consists of the following

1 Relieve pain and muscle spasm
2 Reassure patient with optimistic prognosis
3 Promote healing of injured tissues
4 Exhaust all diagnostic studies, including x-rays and laboratory work if pain is persistent

When sciatic pain appears one must keep in mind the possibility of herniated disk or intraspinal lesion but it is not necessary nor desirable to scare the patient or perform too many laboratory tests at one time other than obtaining good films of the lumbar spine and pelvis, including hips for lower back lesions, dorsal spine and chest films for dorsal spine symptoms, and cervical spine films, including the shoulder and scapula, for neck or upper back symptoms

For minor muscular sprains or aggravation of fibrositis in the soft tissues, injection of 10 cc of one or two per cent procaine will be quite comforting. Sedatives analgesics and hypnotics may be necessary for twenty-four or forty eight hours Low heat and massage is also of benefit. Adhesive strapping sometimes affords comfort, but it may cause a burn in sensitive individuals and is best applied over a circular bandage. The circular bandage also gives better support than a half strapping, which is anchored to the skin, usually too tightly often causing an excoriation which may take longer to heal than the sprain.

More painful injuries of the muscles and ligaments should be treated by bed rest. A firm mattress, with wooden slats or wide board between spring and mattress is helpful at the onset. Later on, the patient is allowed to move about in bed, assuming the most comfortable position, not necessarily flat on his back.

Bilateral Buck's extension is helpful only for a short time Some patients become nervous after a week or ten days

Antiarthritic remedies have proved extremely helpful in painful back injuries and should be employed when fre-

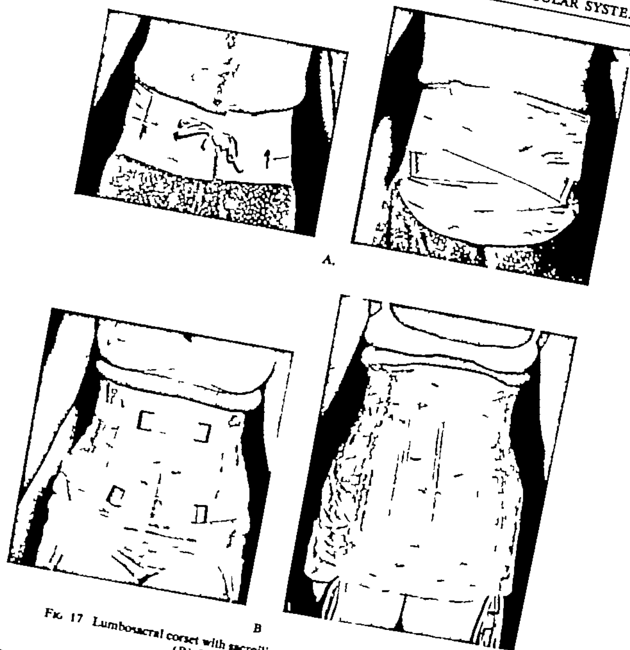
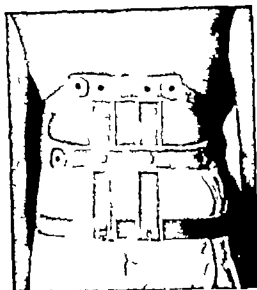
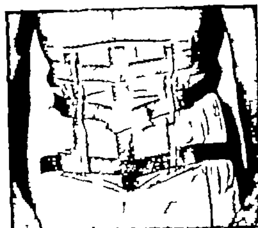


Fig 17 Lumbosacral corset with sacroiliac strap (A) Male—front and rear (B) Female—front and rear

quent sedation does not help Salicylates in full doses cortisone ACTH or butazolidin have been used with gratifying results Whether or not a rheumatic element is present makes little difference to the patient as long as relief is obtained

When back pain lasts more than ten days and tends to linger even with no spasm of muscle it is best to support the back with a brace of some type A light metal support of the McAusland or Williams type is preferred to the corset type because they are not as





A B

FIG. 18 McAusland lumbosacral brace. (A) Rear view (B) Front view

warm in summer They support the back and do not squeeze the patient. It is surprising how well a small belly apron will support the back by tensing the abdominal muscles Women prefer corsets for cosmetic reasons If the sacroiliac joints are involved, the sacroiliac strap may be reenforced with another strap going around the pelvis Back braces are worn by the heaviest laborers and truck drivers with comfort and a feeling of security while working

If pain is acute, heat is not tolerated well and is best withheld until some improvement has been obtained Massage is quite helpful and is desirable after application of heat, in any form.

Various manipulations of the spine have proven helpful in relieving muscle spasm, but the patient must stay in bed if benefit is to last any length of time. Chiropractors and masseurs obtain good results in some cases because they relieve muscle spasm, in addition to gaining the patient's confidence by psychotherapy Nervous tension, which is present in many people with acute, disabling backpain is also relieved by these nonmedical practitioners

If sciatic pain appears, one must enforce bed rest because weight-bearing increases this type of pain and produces more muscle spasm A spinal tap is done to determine the color of the fluid, and the protein, sugar and cell content. The fluid dynamics are studied by manometric studies and the Queckenstedt test. If these tests are negative and the x ray films do not show any important pathology conservative treatment is continued as long as there is improvement. No myelogram is done As soon as radiating pain is relieved and muscle spasm disappears the patient is allowed out of bed with a brace or body cast, depending on the severity of symptoms.

If acute arthritis complicates the picture convalescence may be prolonged for many months. X ray therapy is sometimes advisable in arthritis of the spine if the newer drugs do not prove satisfactory

If sciatic symptoms are not relieved, and there is evidence of root pressure,

especially with depression of sensation and reflexes even when the ankle jerk is only slightly diminished, a myelogram is indicated. Some men do not advocate myelographic studies because of the difficulty in removing the oil, and the possibility of arachnoiditis They would explore the spine on the basis of clinical findings x-rays, laboratory tests, and history of intractable disability This view is supported by a large proportion of eminent neurological and orthopedic surgeons.

When operation is indicated, a laminectomy is done to explore the spine on the side of the sciatic pain The fourth or fifth interspace is the usual site of disk injury but it may be higher Occasionally a caudaequina tumor is found After removal of the disk, the spinous processes are grasped with heavy Kocher forceps and tested for instability by rocking in all directions If there is evidence of instability or if a roentgenogram indicates a potentially weak back from congenital abnormality or from degeneration of intervertebral disk a spine fusion is done with the double clothespin graft of Bosworth including one vertebra above and one below the unstable segment The (H) graft of Moore is also quite suitable.

In some cases of chronic backache without history of sciatica and with evidence of congenital weakness, a spine fusion is done without laminectomy Postoperatively the patient is kept on his back until he has reacted from the anesthesia He is then turned on his stomach every three hours using only an abdominal binder for support Intravenous fluids and blood are given as necessary Prostigmine and rectal tube are used to control distention Bowel movements are not encouraged for two or three days because of pain and to avoid possible contamination of a fresh wound. The diet is kept soft and cathartics are given after the third day to establish comfortable bowel movements. Pain relieving drugs are given as necessary and a sedative is given at night for sleep Empirin compound and antiarthritic drugs are sometimes necessary to control postoperative sciatic pain after the first week

If no spine fusion has been performed, the patient is allowed out of bed in two weeks with a light brace. He can resume his usual duties in six to eight weeks if work is light.

If spine fusion has been performed, the patient is keep in bed for three to four weeks and then allowed up with a heavy brace or cast. Three to six months is sometimes required for resumption of work and, unfortunately in some cases, even longer

Fractures of Cervical Spine

Neck injuries are often associated with blows or falls on the head, causing unconsciousness The patient and surgeon may be preoccupied with the head or other injury and overlook the cervical spine Symptoms may remain latent for months or years, after an apparent trivial injury

Sprains & Strains of Neck

Simple muscle and superficial ligament tears are differentiated from deeper joint injuries by the severity and duration of symptoms, and by the absence of x ray signs If muscle spasm of any degree is present x-rays should be taken including a lateral view with neck in flexion an anteroposterior view of the atlas through the open mouth and an anteroposterior view of the other vertebrae Whenever possible the lateral view should be taken with the pa

tient sitting on a stool and his arms hanging by his sides, with weights in each hand to pull the shoulders out of the way If the films show perfect alignment of all bodies and posterior joints equal disk spaces in flexion as well as extension intact bony texture and normal appearance of odontoid-axis relationships, then symptomatic treatment is given

A collar can be made out of an ordinary newspaper covered with any cloth, towel, or bandage Analgesics are prescribed and a local injection of two per cent procaine is given if necessary

If symptoms linger or are complicated by acute virus infection, bed rest with halter traction and 1.36 kg (3-pound) weight is used for a few days. If the halter is made of unpadded leather or canvas it should be cushioned by simply winding cotton around it, held in place with flannel bandage Sponge rubber padding is the most comfortable. Then it is freely sprinkled with talcum powder

Deep sprains and ligament tears involving posterior-articular facets or other intervertebral ligaments, are treated in bed from the start because symptoms are more acute

A small pillow behind the neck can be used at first, and if relief is not obtained in a few days then traction is applied. As a rule the patient may be allowed out of bed in a few days, with a felt, paper or quilted bandage collar

The latter is made by covering four layers of sheet cotton, one meter (1 yard) long, with any cloth. It is made wide enough to fit snugly between the lower jaw and the sternal notch. The bandage is then criss-crossed diagonally on a sewing machine to make it firm by "quilting" it. The finished bandage is started at the back and then wound around the neck The end is pinned down with a safety pin.

Fracture of Spinous Processes

These injuries are uncommon and are usually seen in the cervical region They are caused by indirect muscle pull and

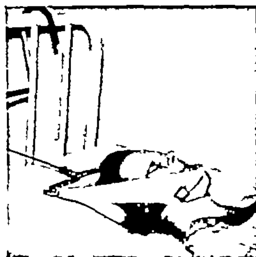


Fig. 19A. Halter traction.



Fig. 19B. Five pound pull in straight line.



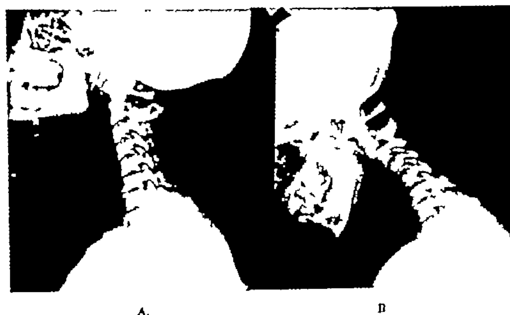
Fig. 20 Plaster collar for neck injuries.

apparently do not occur in the dorsolumbar areas because the processes are thick and well protected by ligaments and do not yield to muscle pull. Direct blows glance off

This fracture is sometimes seen in baseball players who are making a catch with the neck in hyperextension when suddenly they catch the ball and the head snaps forward It has been reported previously as "Clay-Shoveler s Fracture" by Hall who described the mechanism as a sudden pull on the blade of the shovel by the wet clay which sticks to it. As the patient swings the shovel up above his head to empty it the force snaps his head forward and fractures the spinous process, usually the 7th.

Treatment consists in application of felt, plaster or other type of collar until pain and muscle spasm subside

This fracture may not be a simple, isolated injury and should not be dismissed lightly If the flexing force is strong enough there may be a chip fracture of a vertebral body with further damage involving the intervertebral disk or even extension of the fracture through the laminae with injury to the cord. If there are symptoms of root pressure



A. B

Fig. 21 Old unrecognized disk injury with severe root symptoms. (A) Straight position. (B) Anterior flexion.



FIG. 22. Old chip fracture with late symptoms of disk injury

with pain radiating down the arms and possible weakness of the hands, immobilization should be continued for six to eight weeks in a brace or plaster collar

SUBLUXATIONS & REPLACEMENT DISLOCATIONS

When there is a sufficient flexing force applied to the joints from back to front there is rupture or stretching of ligaments forcing the posterior elements to spread apart and the bodies to compress At the same time, there is a forward shearing movement which may go far enough to disengage the posterior facets and fracture the vertebral body in addition the disk may be forced posteriorly through the posterior longitudinal ligament producing cord damage When the force ends and the tissues spring back, the extent of replacement may be complete, so that normal relationships can be found if no fracture or locking dislocation has resulted.

The injury is a serious one and involves all the tissues except for a fracture of the bony elements Complete paraplegia is often seen. When no cord



A.



B

FIG. 23 (A) Fracture of seventh cervical spinous process sustained while catching baseball. (B) Old fracture of third cervical spinous process and injury to fourth and fifth disks in auto accident.

opposite side to use the intact arches on the left side as a fulcrum to thus separate the dislocated facets on the right in the coronal plane. The head is then pulled back to separate the facets in the sagittal plane Having obtained distraction in both planes replacement of the upper facet which has jumped forward can be completed by rotating the head backward and to the right side in a transecting plane All movements are tested and should be free if reduction was successful. A Calot half jacket is then applied with the head in extension.

If the dislocation is bilateral one may use the one-stage traction method of Taylor or employ continuous traction with a halter or skull tongs on a regular hospital bed taking x-rays at fifteen-minute intervals. The patient is best placed with the head at the foot of the bed to facilitate application of plaster Calot jacket with head in extreme extension In the one stage or the continuous methods the surgeon should employ gentle, direct digital or manual pressure about the neck while traction is gradually increased, using a halter The traction apparatus can be attached to a table or bed, or it is strapped to the operator's hips for a one stage reduction leaving his hands free to manipulate Weight is started at 7 kg (15 pounds) in muscular men taking extreme care in making the direction of pull in a perfectly horizontal straight line avoiding extension flexion or lateral slipping to either side The weights are increased by 2 3 kg. (5 pounds) every fifteen minutes and checked with a lateral x ray view until reduction is completed. The weight is then lowered to 2.3 kg (5 pounds) if the halter is used and to 4.5 kg (10 pounds) with skull traction.

If the general condition of the patient permits a plaster Calot half jacket is applied with the head and neck in extreme extension. This is maintained for six weeks and then replaced with a brace for another six weeks depending on the stability of the involved joints and the patient's symptoms.

When paralysis is present or the patient has other complications traction is continued until symptoms allow application of plaster In the event that reduction is not obtained within reasonable time when using a halter Crutchfield tongs must be applied to continue

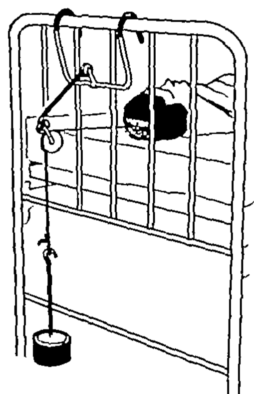


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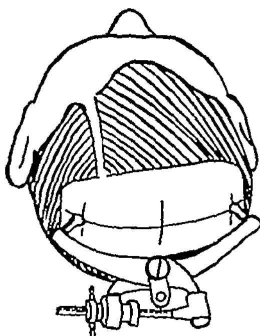


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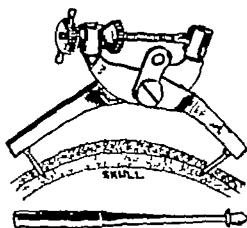
FIG. 27 Posture for application of Calot half-jacket by Watson Jones Method. (A) Board extending up to seventh cervical spinous process for support. (B) Position of patient on table.

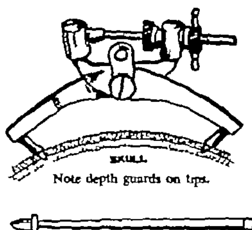


A.



B





C.

FIG 28 (A) Crutchfield skull traction in straight line. (B) Close-up view of tongs. (After W G Crutchfield, J Bone & Joint Surgery 1938) (C) Raney modification on right. (From advertisement in J Bone & Joint Surgery July 1952.)

weights over 1 36 to 2.27 kg (3 to 5 pounds) The halter is very uncomfortable and often requires removal for relief of pressure for shaving and sometimes for pressure sores unless it is well padded. If closed traction and manipulation methods fail, it may be necessary to do an open reduction with wiring and spine fusion as described elsewhere in this chapter

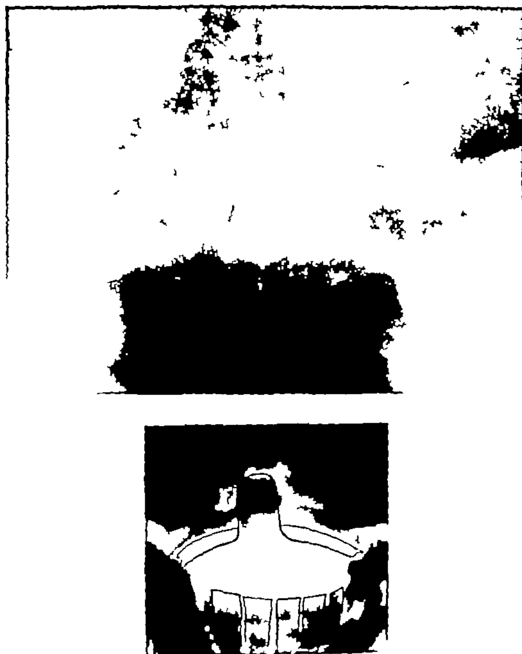


FIG. 29 Anterior dislocation of atlas on axis treated with brace. Adolescent girl. Full recovery Note overlapping facets.

FRACTURES & FRACTURE DISLOCATIONS OF LOWER CERVICAL SPINE

Compression fractures and chip fractures are commonly seen after many types of injuries both minor and severe Minor chip fractures and disk injuries are often overlooked because symptoms may disappear in a few minutes or because of other injuries Months or many years later there may be arthritic changes or root pressure from a herniated, swollen or calcifying disk requir

ing traction, brace or even operation in some cases

Minor fractures should be treated with halter traction, using 1.36 to 2.27 kg (3 to 5 pounds) weight until pain and muscle spasm subside. A brace, plaster collar or Calot jacket is then applied in hyperextension for two or three months or until symptoms disappear

More severe fractures require gradually increasing hyperextension and maintenance of position until some healing has been established, usually about three weeks A Calot jacket is then applied. Cases with paralysis are kept in bed much longer A Calot jacket is then applied in hyperextension or a similar type of brace is used until healing is complete. This requires three to six months of support, but plaster may be replaced with braces after two or three months if there is no danger of dislocation and if pain is absent.

In fracture-dislocation the problem is entirely different and again we must return to the use of gradually increasing traction force by skull traction in bed, using an initial weight of 4.5 to 7 kg (10 to 15 pounds) Where fracture and dislocation exist together more care is required in the use of traction force, because of the uncertainty concerning the strength of the remaining ligaments If the anterior longitudinal ligament is intact, it prevents longitudinal overpull but it cannot prevent slipping laterally anteroposteriorly or in rotation. Rapid reduction is not necessary unless paralysis with spinal block is present. Traction is continued after reduction and 4.5 kg. (10 pounds) is sufficient.

The patient is kept in bed for six weeks to obtain good gumming of ligaments and bone A small pillow behind the neck can be added and weights can be reduced to 2.27 kg (5 pounds) after two or three weeks After six or eight weeks a Calot half jacket or brace is applied from chin to lower chest, with neck in hyperextension This is continued until union is solid, usually three to six months Do not hesitate to prolong immobilization in fracture-dislocations. These are unstable and will continue to slip later if not watched for long enough periods.

APPLICATION OF CRUTCHFIELD TONGS

The principle is based on the use of the outer table of the skull near the top of the head, to anchor the tips of the tongs for traction. When the tongs are properly applied and locked in place they usually do not go deeper or slip out. Occasionally infection develops or the tongs pull out. If necessary they must be reapplied and traction is continued.

The procedure is begun by shaving a rectangular area at the top of the head from side to side reaching both temporoparietal areas clearing a swathe about 7.5 cm. (3 inches) wide, keeping it at about the level of the mastoid processes and ears

To mark the point of insertion, the tongs are opened wide so that the tips reach the prominences of the parietal bones on each side the hinge is held in the midline and a transverse line is painted or scratched on the scalp under aseptic precautions, connecting the prongs on each side in line with the hinge Three short crossmarks are then made at the points where the hinge and prongs coincide with the transverse line The tongs are laid aside and the points of entrance are infiltrated with two per cent procaine on each side to allow short 12 mm. (one-half inch) incisions on the scalp down to the bone. Cuts are made transversely in the same direction as the main line running from

side to side The bone is exposed and the periosteum is pushed aside with the knife blade A hole is then drilled on each side of the skull with a special drill point, having a circular depth guard to insure penetration of the outer table only The points of the Crutchfield tongs are then fitted into these holes and the tongs are tightened carefully before locking them A rope is attached to the specially made metal loop at the hinge and this is run over a pulley A weight-carrier is then attached to the rope and the weights are added, as desired.

The Raney modification makes these tongs almost foolproof by adding guides to the prongs so that penetration into the dura is prevented and better purchase or grip is obtained by pressure of the guide against the skull

T C Thompson reports a simple technic using modified fish hooks inserted under the zygomatic process of the temporal bone similar to the Roger Anderson apparatus The barb is apparently filed down and the hook is made of rustless metal for use in the tissues Hoen wires are used like tongs passed through double drill holes in the outer table They are cumbersome to apply

Dislocation of the Atlanto-Occipital Joints

This injury is very rare just as isolated dislocations of the lumbar spine The atlas is snugly nested against the skull by a pair of elliptical joints which allow only flexion and extension and some lateral flexion to either side A minimum amount of diagonal movement is also permitted but no rotation is possible because of the locking action of the oval contour of these joints whereby the anterior portion of the joint on the one side becomes jammed against the skull simultaneously with the posterior portion of the opposite side The powerful surrounding ligaments help to maintain its integrity and prevent dislocation.

The foramen magnum and vertebral opening of the atlas are very spacious and allow the cord to move with considerable freedom For these reasons compression of the cord at this point is not common.

A dislocation of this joint is best treated by padded halter traction or skull calipers, if necessary X rays including view through the open mouth are taken to follow progress of reduction. A Thomas brace or Calot half jacket is then applied with head and neck in neutral position. Fixation is maintained for two to three months Saul Ritchie devised an effective modification of the Calot jacket by using a chin strap buckled to the head band. This allows the patient freedom in eating, shaving, and washing of face

Fracture of the Atlas

A blow or fall on the head transmits force through the atlanto-occipital joint, causing spreading of lateral masses and fracture through weak posterior arch. If the force is greater there may also be a fracture through the anterior arch

According to Watson-Jones there is no cord lesion in half the cases and the prognosis is good apparently due to the spaciousness of the vertebral foramen in this vertebra

The usual symptoms of neck injury are noted, such as pain muscle spasm tilting of head, and inability to raise the head from the pillow unassisted The patient often lifts his head between his

hands to change position Headache with involvement of the great occipital nerve may be noted

Treatment consists of plaster immobilization in a Calot jacket down to the chest or pelvis with the head and neck in neutral position. Light traction with padded halter and 1.36 kg (3 pounds) of weight may be applied while waiting for cast If there is cord involvement, the patient must be kept in bed with skull traction until some union is obtained to stabilize the fracture

All fractures and dislocations of first three vertebrae have a tendency to be unstable and often require open reduction with wire fixation and bone grafting for permanent cure

Operation can be done in a Calot jacket through a posterior window or with continuous skull traction by the method of Rogers of Boston.

In dislocations, the forward slipped vertebra is pulled back and wired to the spinous process immediately below If there is a compression fracture the process is reversed because the injured vertebra is the unstable one and abnormal mobility occurs between itself and the vertebra immediately above

If the neural arch is fractured in addition to the body one must use the next or adjoining intact vertebra to avoid distraction of the neural arch fracture

FORWARD DISLOCATION OF THE ATLAS

This injury is caused by a combination of rotation and flexing forces The atlas is held to the skull by the powerful atlanto-occipital joint. It moves forward, stretching the weak atlantoaxial ligaments and as the force increases the ligaments are ruptured, causing the atlas to move forward, bringing the cord and skull with it. The part of the cord between the atlas and axis impinges against the odontoid process or epistropheus, causing almost certain death in most cases If by chance the patient lives he may be hopelessly paralyzed, but in rare instances there may not be any paralysis Chronic instability is common.

Treatment consists in bed rest with light, padded halter traction, sand bags or pillows about head and neck, or skeletal traction, if necessary If paraplegia is present, the treatment is bed rest on air mattress, proper nursing care



A. B.

FIG. 30 Fracture of axis through pedicles with minimal anterior subluxation. (A) AP through mouth. (B) Lateral. Treated with brace.



A. B

FIG. 31 Anterior dislocation of atlas on the axis with fracture through the base of odontoid process and right articular process of axis. (Fracture-dislocation of odontoid process.) (A) AP through mouth. (B) Lateral.

Treated with brace only Patient removed brace and dislocation recurred spontaneously No cord injury Recovered completely with brace. Fell at home



A. B.

FIG. 3_ Fracture of odontoid process sustained from striking forehead against wind shield of truck. (A) AP through mouth. (B) Lateral.

Treated by bed rest.

and starting of tidal drainage for care of bladder Traction is continued for six weeks

Myositis ossificans and periarticular bony ankylosis of the joints in the upper extremities constitute a rare but trouble some complication in cervical cord injuries with paraplegia. If symptoms clear up sufficiently the patient is placed in a Calot jacket or the cervical brace of Forrester or Thomas designs Immobilization may be required for several months to prevent recurrent instability requiring wiring of axis to skull and fusion with bone grafting

Fracture Dislocations of the Axis

If the flexion and rotation force is great enough and if the odontoid process is held firmly in place by the ligaments around the arch of the atlas this process will detach itself by a type of avulsion fracture, causing a relative enlargement of the vertebral foramen of the atlas, permitting a certain amount of forward excursion of the cord without injury In this instance paralysis is not a problem and treatment for the fracture-dislocation alone is planned. The neural arch or body of the axis may be fractured

The patient is put to bed with a small pillow behind the neck in the extended position A Calot jacket from head to pelvis is applied and fixation is continued for three to six months This injury may be unstable and it is often preferable to do an open reduction with wiring and fusion of the first three vertebrae In late cases with instability the bone graft is fixed to a hole in the occipital bone

Hyperextension Injuries of the Cervical Spine

A severe blow to the forehead or fall on the face may produce combined fracture-dislocations in any portion of the cervical spine. It is a dangerous injury in arthritic spines which are already ankylosed in hyperextension The anterior longitudinal ligament alone may be ruptured which does not show on routine x-ray examination. The odontoid process can be fractured by the anterior arch of the atlas

Treatment is started in bed with neck supported in neutral position by small pillows and sandbags No traction is used for fear of causing dislocation with cord damage When symptoms subside a cervical brace or plaster collar is applied in neutral position If the force is greater there may be a fracture of the posterior half of the atlas or axis and in some cases, both neural arches are involved The axis may rock back on the third vertebra with varying amounts of cord damage

It is extremely important to avoid extension These are the injuries which confuse the best surgeons and give rise to repeated warnings against the indiscriminate use of hyperextension methods It is not too radical to repeat here that more damage may be added to any spine injury by active postural, manipulative or operative intervention than by passive guided nursing care on a comfortable bed

In these hyperextension injuries, the patient is made comfortable in bed with pillows and sandbags about the head until it is feasible to apply a Calot jacket down to the costal margin or pelvis with the head and neck in the neutral position This cast is kept on for three months

No attempt is made to flex the spine because cord damage is likely if there is comminution of fragments

In the lower cervical vertebrae there

may be crushing of the laminae with pressure on the cord

Skeletal traction is indicated if there is paraplegia. If spinal block is not relieved open reduction and laminectomy is indicated. No casts are used in paraplegia

Late Dislocations of Cervical Spine

The atlantoaxial joint may become permanently unstable following an injury or infection The patient is always in danger of sudden death from a slipping forward of the atlas on the axis. Fresh dislocations may result from a focus in the upper respiratory tract following an ordinary cold This is often seen in children who suddenly get a stiff neck several days or more after an upper respiratory infection. If the acute symptoms are not treated promptly until all pain, muscle spasm, and deformity disappear the joint may be weakened just as in an old fracture or dislocation. In the lower cervical spine the process is a slowly progressing one which gives ample time for treatment of the condition. This results from an old malunited or unrecognized fracture or dislocation The acute injuries are treated in a plaster jacket for three months If symptoms continue or recur after varying intervals of time, the best treatment is skull traction until the bones are in satisfactory alignment. A Calot jacket is applied for three months and a window is cut behind the neck for spine fusion in the plaster jacket.

In case of atlas on axis dislocations the first three vertebrae are fused to the skull with a bone graft from the iliac crest. In the lower cervical spine one vertebra above and one below is in

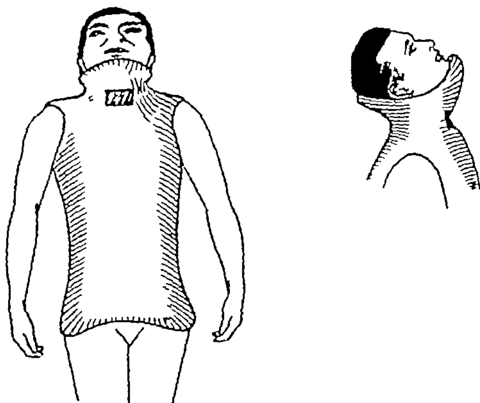


Fig. 33 Full Calot or Minerva jacket.

cluded in the fusion of three vertebrae There can be sudden death from sneezing or coughing even in the plaster jacket. When the spine is rigid or stiff from widespread arthritis care should be exercised at all times

No surgery should be done without a Calot jacket because operation causes temporary relaxation and greater instability for a week or two due to cutting, stripping and reactive inflammation The patient is in danger unless the neck is properly immobilized Continuous skull traction is efficient but serious accidents can happen if weights or apparatus slip Weights up to 18 18 kg. (40 pounds) are sometimes needed to relieve symptoms preliminary to spine fusion.

FRACTURES OF THE PELVIS

Visceral and vascular damage is more important than bony deformity The severest sequelae of bony deformity are pain in the hip or back which are often amenable to reparative orthopedic surgery A ruptured bladder urethral laceration or torn blood vessel may terminate in death—which is final. The percentage of serious cases in any given locality depends on the type of accident peculiar to that region. This consideration is immaterial in the treatment of any given case The important factor to keep in mind is the prevention of sepsis and the arrest of hemorrhage It is difficult to forget a patient who has died within a few days from infection or hemorrhage after the bony deformity has been beautifully and simply corrected within a matter of two hours Bladder ruptures do not respond to antibiotics without surgery Massive hemorrhage will not respond to transfusion without exploration and packing

A lacerated urethra or intestine needs emergency surgical intervention

Fractures through the sacroiliac joint with or without separation of the symphysis pubis or fractures of the acetabulum may leave some disabling symptoms but these injuries are not fatal

Every case of fractured pelvis is an emergency until proven otherwise A catheterized specimen of urine should be obtained immediately and examined for blood both grossly and microscopically A dry catheterization or the presence of red blood cells even microscopically should arouse suspicion of ruptured bladder When this catastrophe is even suspected, a cystogram must be done at any hour of the day or night by injection of 600 to 900 cc (20 to 30 ounces) of a radio-opaque liquid through the catheter and x ray examination with portable machine at the bedside if the patient cannot be moved to cystoscopy or x ray room This is a simple procedure and may be life saving.

The presence of ruptured bladder necessitates prompt surgery to avoid a fulminating sepsis from extravasation of urine Peritonitis is the common cause of death. When the rupture is around the neck of the bladder or posterior urethra, the symptoms may come on more gradually with the development of an abscess in the retroperitoneal tissues, perineum or fascial planes of the upper thigh.

Compound fractures of the extremities and fractures in other parts of the body are common with severe crushing injuries in falls from heights *Head* and *chest* injuries require prompt evaluation and treatment. Blood plasma, electrolytes whole blood, and antibiotics are given promptly

Retroperitoneal hemorrhage is difficult to treat because of the inaccessibility of the pelvic arteries and veins, but mas-

sive packing *should be attempted rather than watch a patient bleed to death even while we are pouring fresh blood into his veins*

Ruptured intestines or a perforated uterus require more deliberation at the beginning because of the hidden signs and associated symptoms of surgical shock and hemorrhage However with exclusion of a ruptured bladder or urethra and lack of positive signs of hemorrhage one can suspect some other *visceral emergency if surgical shock continues and the temperature takes a septic course*

Compound fractures or penetrating injuries of the pelvis are treated the same as other compound fractures. Careful debridement is done and local antibiotics are applied to the wound Drainage is desirable for the hematoma which may develop The skin is sutured with silk

It is evident that emphasis has been placed on the recognition and emergency surgical treatment of visceral in*jury and hemorrhage rather than on the pelvic fracture*

When the soft tissues have been repaired and hemorrhage arrested, reduction and immobilization of the fracture will reduce shock and promote better healing of all tissues, both visceral and osseous

This stand concerning the importance of visceral injuries does not detract in the least from the fact that prompt treatment of a fracture or dislocation will help *the management of other injuries* However the soft tissue lesions threaten life more than the bony deformity and must be given first consideration.

Treatment of Pelvic Fractures

The most practical apparatus for the management of displaced fractures is the pelvic sling as described by H Earle Conwell of Birmingham Alabama. It can be pointed out that it affords some of the advantages of the bilateral plaster spica in lateral recumbency described by



A



B

Fig. 34 (A) Comminuted fracture of the acetabulum and upper shaft of the femur fracture of both pubic rami. Treated with skeletal traction. Recovery with 2.5 cm. (1 inch) shortening and slight restriction of motion, but no pain (B) Same as (A) eight months later



FIG. 35A Wide separation of symphysis pubis with fracture-dislocation of left sacroiliac joint, dislocation of coccyx unrecognized ruptured bladder neck perineal abscess. Died of sepsis without surgery on tenth day

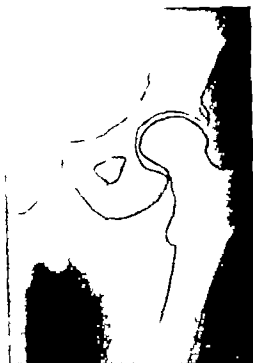


FIG. 35B Reduction of symphysis separation by lying on left side in pelvic sling. Reduction maintained even on back by pulling sling together

Watson-Jones of England, without some of the disadvantages

If skeletal or adhesive traction is necessary it can be easily applied and utilized at any time during treatment. With the sling suspended under a Balkan frame, the patient can be treated on his back the lateral pressure of the sling being adjusted to maintain reduction If the patient is turned on the side which is injured the weight of the patient will exert sufficient lateral pressure to maintain reduction. Quite often, a wide open separation of the symphysis pubis with fracture through one or both sacroiliac joints will close like a book as soon as the patient is placed in the sling on his injured side

Anesthesia is often not necessary if there is no serious dislocation or distortion of the pelvic ring When manipulation is necessary a general anesthetic should be given.

The turn-buckle method of S A. Jahss is quite useful in crush fractures where lateral traction or pulling apart of the fragments is desired This cannot be done with the pelvic sling alone. Moreover it can also be used equally well for bringing together of a spread out fracture by changing the position of the turn-buckles on the leg casts The principle is based on the use of the legs as levers acting on the hip joints to pull out or press together the sides of the pelvis Here again there are disadvantages because of frequent pressure sores, and in some cases pressure paralysis of the sciatic nerve It is contraindicated in cases with associated cord damage because of impaired skin circulation and sensation. An added disadvantage is the absence of traction if needed to reduce vertical displacements The Roger Andersen well leg skeletal traction apparatus is ideal for this purpose and can be modified to work with turnbuckles in reducing crushed-in or spread-out fractures besides vertical displacements according to the technic of ...

L

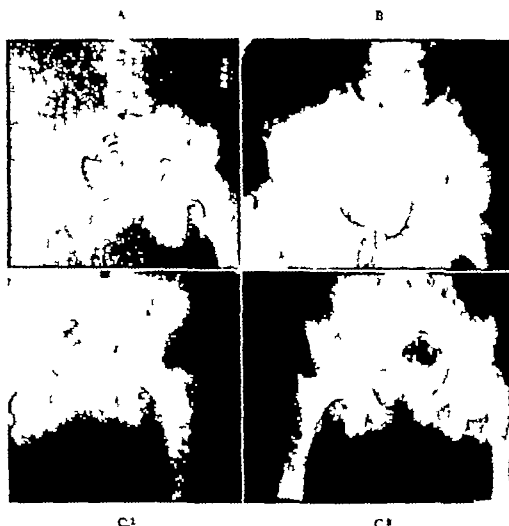
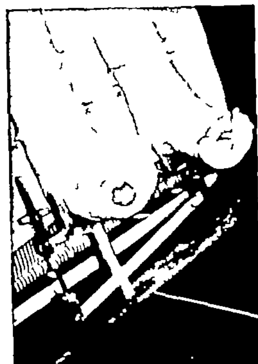


FIG. 36 (A) Comminuted fracture-dislocation of entire left side of pelvis with marked upward displacement of ilium and separation of symphysis. Patient fell out of second floor window and fall was broken by metal bar which caused the above type of injury (B) Closed reduction by manipulation under general anesthesia, and application of Roger Anderson well leg traction splint, according to method of E. L. Jewett and with Silver Rusbridge modification of Jahss Turnbuckle Technic. Pelvic sling used for molding action. Overreduction of acetabulum and symphysis. (C)[1] Wooden block and strap in reverse—position improved Patient entirely comfortable Cystogram essentially negative except for slight irregularity from pelvic hematoma. No complications. (C)[2] Final x-ray

Jewett. He uses an extra long bar on the Roger Andersen apparatus to bring the hips out into more abduction and a Steinman pin through the tibia on the well leg besides the one for traction on the other leg to remove the possibility of excessive pressure on the sole of the foot. The casts are carried to the upper thighs. The turnbuckle is placed between the knees or lower thighs and the strap is passed around the casts at the midportion of the legs. A simple modification of Jahss turnbuckles was developed by Caroll M Silver and Harold W Rusbridge who utilize a block of wood 15 cm (6 inches) wide and 5 cm. (2 inches) thick placed transversely between the cylinder casts at the upper or lower end depending on the type of fracture using a strap to


D


E.

FIG. 36. (D) Roger Anderson apparatus for longitudinal traction with two Steinman pins. (E) Compression effect with strap and wooden block in place.

bring the lever arms of the casts together If spreading of the pelvis is desired the strap is placed at the lower end and the wood block at the upper If compression is needed, the position is reversed but the strap is tightened for reduction in either case

It must be remembered that in these double cast technics it is necessary to use adequate felt padding over bony prominences

Lastly but of equal value in obtaining distraction of fragments one can use the simple but satisfactory procedure of skeletal traction through the trochanteric region of the femur by transfixing with a wire or Steinman pin or using a screw cork-screw bolt, or nail in the base of the femoral neck. The traction rope passes laterally and slightly diagonally towards the foot of the bed to pull in line with the neck of the femur and ligaments of the hip joint.

Having stressed the importance of prompt emergency treatment of bladder and other visceral injuries and after outlining several excellent methods of treating complicated displaced fractures, it behooves us to focus some of our attention on the fact that the majority of pelvic fractures heal with very little or no permanent functional disability with simple bed rest. Bony union is practically insured in all cases because of the rich blood supply in cancellous bone The fragments will unite as long as there is some degree of contact at some point. Separated joints or epiphyses will not unite by bony union, but residual symptoms are mild except with injuries of the sacroiliac joint and acetabulum where painful residual symptoms and

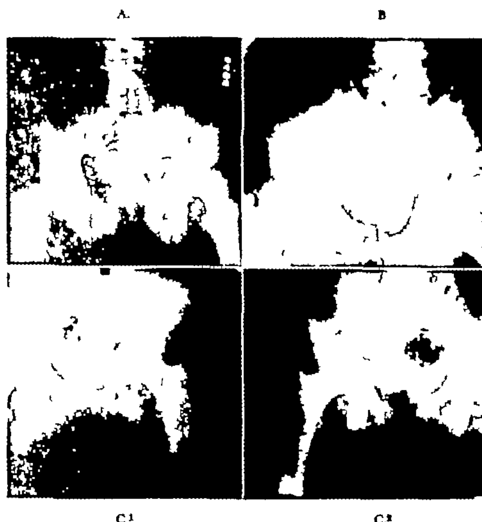
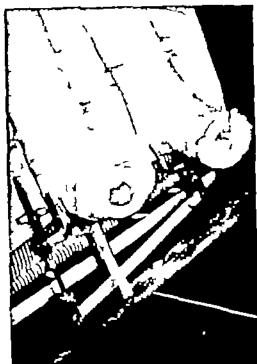


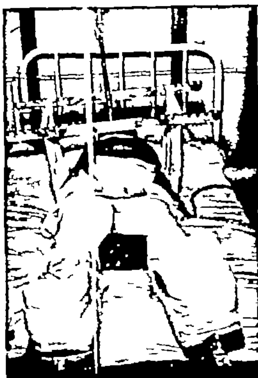
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traumatic arthritis are commoner It is surprising to see relatively good function even with considerable separation of the symphysis pubis where some distortion of the sacroiliac joint is always present.

Anatomy The pelvis forms a ring which is joined posteriorly at the sacroiliac joints by powerful ligaments and in front at the symphysis pubis by a comparably strong fibrocartilaginous union The pubic joint has a small surface area compared to the sacroiliacs and is more easily ruptured than the sacroiliac joints However there must be severe rupture of the sacroiliac ligaments or fracture of the pelvic ring in this region or at one or both of these joints to allow separation of the symphysis pubis beyond 2.5 cm (1 inch) Encroachment on the birth canal in females may occur at any point in the pelvis following pelvic fracture

The coccyx rarely causes any permanent discomfort and does not interfere with parturition unless it is rigidly fused to the sacrum by bony continuity in a deformed position

The acetabulum assumes considerable importance because it forms the socket for the head of the femur and gross displacements in any direction will lead to crippling traumatic arthritis of the hip Chip fractures indicate a probable replacement dislocation of the head of the femur and must be studied carefully because weight bearing should not be permitted for three months in a fracture dislocation of the hip joint.

Vertical displacement of the pelvis over 12 mm (½ inch) may cause a limp due to shortening of the extremity With rotational displacements, there may be faulty mechanics due to strain on the lumbosacral, sacroiliac and hip joints

Symptoms Localized pain and tenderness are the most constant signs in fractures of the pelvis There may be more than one area of involvement and muscle tears near the pelvic attachments may simulate fracture Points of tenderness are often found along the inguinal regions or pubic areas, along the iliac crests or over the sacrum, coccyx, or tuberosities Fractures of the acetabulum may cause painful and restricted hip motions Local swelling, hematoma and ecchymoses are common findings. If the fractures are more severe, there will be various abdominal signs including distention Compression of the wing of the ilium or of the hips may elicit pain Hemorrhage and edema around sacroiliac joints may cause referred pain down the leg to the foot from pressure on the sciatic nerve Crepitus is not a common finding unless there is comminution

Diagnosis is made by x ray examination

Fracture of Pubic Bone

This is the commonest type of fracture and usually involves one ramus either superior or inferior When one side is involved and only one ramus is fractured there is no appreciable displacement because the other ramus maintains the continuity and strength of the pelvic ring Rest in bed and bandaging held with adhesive will relieve acute symptoms The patient is allowed out of bed in a wheel chair or with crutches as soons as comfort allows, usually within one week of injury Crutches are discarded at four to six weeks if x rays show beginning effacement of fracture line. Periosteal and ligamentous pain may persist a while longer and a cane may be used.

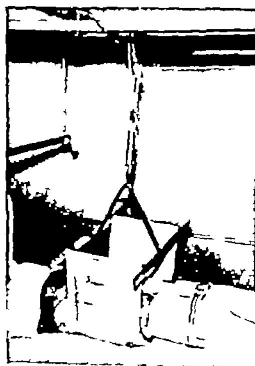
Fracture of Both Rami

If there is no gross displacement, bed rest is sufficient until healing is well advanced, usually in three to six weeks The patient is allowed out of bed with crutches as soon as comfort permits Elderly patients can be allowed to dangle their feet for short periods daily at three weeks If there is considerable displacement of fragments the treatment depends on the direction in which displacement has taken place If the fragments have been pulled apart they must be compressed and held in that position either with a pelvic sling and lying on the injured side or by the lateral recumbency technic of Watson-Jones employing a short double hip spica from the costal margin to the lower thighs applied with the patient in this position lying on the pelvic rest of the fracture table on his injured side These compression technics must not be employed in compressed fractures for obvious reasons and we must use a distracting force in order to pull the fragments apart. In a unilateral fracture of the ilium ischium pubis or acetabulum where the fragments have been pushed into the pelvis we may apply traction to the greater trochanter of the femur in order to pull the fragments into better position and to relieve undue pressure on the pelvic organs If the fracture is bilateral or if difficulty is encountered from too much pull on one side skeletal traction can be applied to both trochanters, at least until reduction is attained. The weights can be gradually lessened if it is found necessary to do so

A better apparatus, but one which requires exacting care to prevent pres-



F



G

FIG. 36. (F) Lateral distraction effect with reversed position of strap and block. (G) Pelvic sling for molding action on bones. Also aids in lifting patient using block and tackle.

sure sores or even pressure paralysis of the sciatic nerve is the double leg cast method of S A Jahss using a turnbuckle between the thighs and one between the legs The Rusbridge modification utilizing a simple block of wood 15 cm (6 inches) wide and 5 cm (2 inches) thick with an ordinary belt to bring the lever arms together works equally well. The Jahss technic with its various modifications can be used either with compressed or with distracted fractures by changing the forces applied to the casts

In vertical fractures with over riding where there is gross upward displacement of the entire side of the pelvis with one intact side, skeletal traction is applied by passing a Steinman pin through the lower end of the tibia about 5 to 7.5 cm (2 to 3 inches) above the ankle The fracture is manipulated under anesthesia to break up impaction and to determine the degree of mobility of the fragments 4.5 kg (10 pounds) weight is used to begin reduction and this is increased as desired. Too much traction must be avoided at first because overreduction can occur and all forces will have to be reversed

Countertraction can be obtained by placing a padded box or block of wood under the foot of the opposite leg so that the patient will not be pulled down in bed The bed is raised on blocks to utilize the weight of the body for counter traction

A more efficient apparatus is the one devised by E. L. Jewett, using a Roger Anderson splint with Steinman pins



Fig. 37 Comminuted fracture of left inferior and superior pubic rami, ruptured urethra, injury to obturator nerve sepsis. Complete recovery

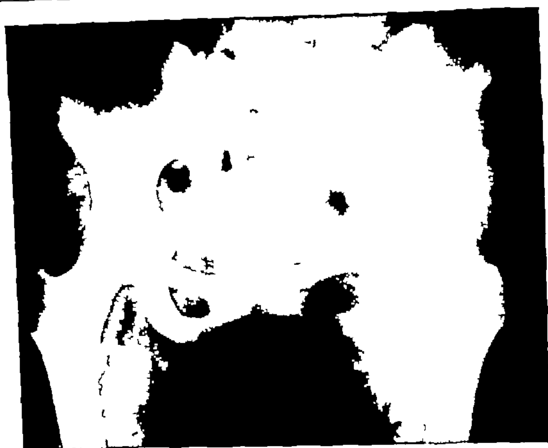


FIG. 38A. Fracture-dislocation of right lumbosacral joint, fifth lumbar transverse process, and spinous process and fracture through right wing of sacrum with mild paraplegia. Treated by rest in bed and brace. Residual hyperactive reflexes on right, slight weakness of left quadriceps.

through both legs This has the advantage of fixed traction which allows easier nursing care The patient can be turned and may be gotten out of bed at an earlier date in severe fractures These cases require bed rest for eight to twelve weeks

FRACTURES OF WING OF THE ILIUM

If there is no displacement, the usual preliminary bed rest for one or two weeks is sufficient, if the symptoms allow Circular strapping around the pelvis just below the wing to use gluteal muscles as a support will give comfort. Cases with slight displacement need longer period of rest and some type of circular binder or strapping. When gross displacement is present, closed reduction must be attempted under anesthesia Bimanual compression and molding can be done or the patient may be turned on the good side in order to obtain greater force in compressing the fragment, if necessary A tight circular support is applied with felt padding in old people or any snug binder can be used to insure some measure of immobilization. Adhesive and moleskin may cause excoriation in sensitive patients or elderly people. As a rule there is too much irregularity and elasticity of the soft tissues to expect rigid immobilization. A sacroiliac or polo belt can



Fig. 38B Fracture of fifth lumbar spinous process. Same case as Fig. 38A.



Fig. 39 Minor avulsion of anterior inferior spine treated with crutches after ten days in bed.

also be used If there is distention of the bladder or intestines the patient may be uncomfortable with the slightest pressure over the suprapubic area.

Persistent gross displacement is best treated by open reduction and wiring with several interrupted sutures The exposure is made subperiosteally starting along the crest of the ilium and working downwards or posteriorly as indicated Postoperatively convalescence is rapid and the patient can be gotten out of bed within a week or two keeping more robust patients in bed longer Crutches are used until healing is well advanced usually about four to six weeks

Fractures of the Anterior Superior and Inferior Spines of Ilium

These are usually avulsion fractures and heal readily Any minor displacement, even with rotation of the fragment and separation of a degree, resulting in fibrous union, will heal with no loss of function and without pain Small fragments will cause no difficulty even with displacement The sartorious muscle origin and the attachment of Poupart's ligament will reattach themselves at a slightly lower level and no residual defect will remain Larger fragments include the attachment of the tensor fascia lata and if displacement results in fibrous union with deformity some residual discomfort can be anticipated. The same reasoning holds true in avulsion fractures of the inferior spine where the rectus femoris is attached

In the more severe cases if age is not a contraindication open reduction and wire suturing are done. The patient is allowed out of bed in a few days with crutches The less severe cases are treated symptomatically Rest in bed with ice bag for a few days then protected weight bearing with crutches for about four weeks

Paul B Steele sometimes uses a single plaster spica up to the knee with the hip in 110 degrees of flexion The patient is allowed up on crutches as soon as the acute pain subsides.

Minor Separation of Symphysis Pubis

Acute injuries may reveal local signs of pain and tenderness without x ray evidence If the separation has reduced

itself when films are taken In this case it is best to take horizontal views with the tube centered at the symphysis and the patient standing first on one leg and then on the other If there is abnormal mobility some separation can be demonstrated by this procedure During pregnancy there is occasional pain over the symphysis due to physiological relaxation of ligaments If the minor separation is of long standing or of congenital origin, no difference in the level of the pubic bones will show on the two separate films taken as described

Bed rest is necessary for acute injuries and also for pregnant women because any appliance which is worn can give only partial support in weight bearing Crutches are desirable in some cases but many individuals prefer not to use them if they are more comfortable in bed

Gross Displacement of Symphysis Pubis

Reduction is best done by the closed methods described above because operative methods involve subperiosteal stripping in a potentially infected area and because metallic fixation, whether by wire or screws, does not speed recovery

In some cases there may be downward displacement of the pubis with separation of the symphysis due to fracture at the acetabulum. The fragment can be pushed upwards and towards the midline by manual pressure under the ischial tuberosity

If closed manipulation fails and separation of the symphysis pubis is over 2.5 cm (1 inch) with overriding and deformity of the acetabulum then open reduction with subperiosteal exposure and wiring must be considered. If the acetabulum is intact, operation is usually not necessary even with deformity

We must remember that the sacroiliac joints are injured also and must be allowed to heal well before weight bearing Bed rest is necessary for two to three months

Dislocation or Subluxation of Sacroiliac Joints

These conditions are not common as isolated injuries because of the powerful ligaments supporting these joints from top to bottom The symphysis pubis is also a powerful stabilizer of the pelvic ring and the large, irregular surface areas seem to interlock for greater stability When some great force causes subluxation or dislocation of these joints there is severe pain and if reduction is not complete, there will be residual pain and disability requiring fusion at some later date Lifting injuries do not affect these joints as commonly supposed, except indirectly in a small percentage of cases where muscle tears of the lumbosacral or gluteal muscles occur at or near their attachments to the superficial portions of the sacroiliac ligaments.

Manipulation is performed under anesthesia and the Pitkin maneuver is done by rotating and flexing the ilium on the sacrum while the patient is in the supine position. The procedure is done on both sides and then the pelvis is flexed on the abdomen in an attempt to rotate the pelvis on the sacrum A circular strapping is then applied around the ilium between the trochanters and iliac crest, using the gluteal muscles as elastic supports

Fracture of the Ischial Tuberosity

This is usually an isolated injury from indirect violence causing an avulsion of the bone with the origin of the hamstring muscles It can come from a fall

on the buttocks Minor displacements are treated by recumbency in bed for one or two weeks followed by partial weight-bearing with crutches.

Gross displacements are best treated by open reduction and fixation either by wire suturing of periosteal or bony attachments or by screw fixation. The tuberosity is subcutaneous and is easily approached by a transverse or vertical incision with the patient on his back in the lithotomy position. Dissection is subperiosteal and care is taken to avoid injury to perineal structures The Milch approach is used

Postoperative bed rest or plaster fixation varies with the individual case

Fracture of the Sacrum

This injury is produced by direct force usually from a fall on the buttocks or a severe blow to the back. There is very little or no displacement and the patient may limp around from the first day if the pain is not severe The sacral nerves may be injured

Rest in bed may be necessary for a few days followed by circular strapping and support until healing is well established

Fractures and Dislocations of the Coccyx

Conservative measures are always indicated and operation is rarely necessary either early or late All cases obtain some measure of relief by strapping of buttocks together so that the gluteal muscles meet in the midline to splint the coccyx and to relieve some of the pull from the fascial attachments of the muscles and subcutaneous fat

If adhesive tape is irritating, circular flannel bandage can be applied under the adhesive

Certain cases will need closed reduction or simple manipulation under local anesthesia or caudal block using one or two per cent procaine The coccyx is grasped with the thumb and index finger while doing a rectal examination and gentle manipulation or molding is carried out as necessary A strapping is then applied Healing takes about six weeks while the patient is ambulatory If open reduction is necessary it is best removed entirely

Pain may persist or recur but operation should never be done for pain alone There must be some external anatomical deformity of sufficient degree to warrant correction Removing the coccyx may leave the rigid tip of the sacrum exposed to pressure which can be more disabling

Exposure of Pelvic Bones

The entire crest of the ilium from the anterior superior spine to the posterior superior spine is practically subcutaneous and can be exposed by an incision along its outline By subperiosteal dissection, using a sharp chisel tipped with gauze the wing of the ilium can be exposed to the acetabulum

The superior border of the symphysis pubis is also subcutaneous and is exposed with a transverse incision Too extensive stripping must be avoided because of the interference with the blood supply which may lead to aseptic necrosis and possible osteomyelitis

The superior ramus of the pubis can be approached retroperitoneally by a transverse incision exposing the anterior superior spine and iliopsoas muscle working medially by subperiosteal dissection taking care not to injure the iliac vessels and nerves This incision can be combined with the pubic incision

The ischium is exposed by the Milch technic placing the patient in the li

thotomy position. The tuberosity and both ischiopubic rami are subcutaneous and the incision is made along this line This exposure can be quite extensive if necessary It was described by Milch for resection of the ischium and is a classical lesson in surgical anatomy The dissection is subperiosteal, but many important structures may be encountered if the procedure is extensive.

Approach to the sacroiliac joint posteriorly is made by the Smith Peterson technic over the posterior superior and inferior iliac spines The stripping is carried over the wing of the ilium and, if necessary in a medial direction towards the sacrum The joint itself is best exposed by making a window in the ilium opposite the sacrum

The sacrum is exposed by midline incision similar to the description of exposure of the spine. Subperiosteal dissection prevents bleeding and this should be done by using a sharp chisel tipped with gauze

The coccyx is subcutaneous and is easily exposed by midline incision with subperiosteal technic It should be disarticulated from the sacrum first and then removed by stripping from above downwards

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on the buttocks Minor displacements are treated by recumbency in bed for one or two weeks followed by partial weight bearing with crutches

Gross displacements are best treated by open reduction and fixation, either by wire suturing of periosteal or bony attachments or by screw fixation. The tuberosity is subcutaneous and is easily approached by a transverse or vertical incision with the patient on his back in the lithotomy position. Dissection is subperiosteal and care is taken to avoid injury to perineal structures The Milch approach is used.

Postoperative bed rest or plaster fixation varies with the individual case

Fracture of the Sacrum

This injury is produced by direct force usually from a fall on the buttocks or a severe blow to the back There is very little or no displacement and the patient may limp around from the first day if the pain is not severe. The sacral nerves may be injured.

Rest in bed may be necessary for a few days, followed by circular strapping and support until healing is well established.

Fractures and Dislocations of the Coccyx

Conservative measures are always indicated and operation is rarely necessary either early or late All cases obtain some measure of relief by strapping of buttocks together so that the gluteal muscles meet in the midline to splint the coccyx and to relieve some of the pull from the fascial attachments of the muscles and subcutaneous fat.

If adhesive tape is irritating, circular flannel bandage can be applied under the adhesive

Certain cases will need closed reduction or simple manipulation under local anesthesia or caudal block, using one or two per cent procaine The coccyx is grasped with the thumb and index finger while doing a rectal examination, and gentle manipulation or molding is carried out as necessary A strapping is then applied Healing takes about six weeks while the patient is ambulatory If open reduction is necessary it is best removed entirely

Pain may persist or recur but operation should never be done for pain alone There must be some external anatomical deformity of sufficient degree to warrant correction. Removing the coccyx may leave the rigid tip of the sacrum exposed to pressure which can be more disabling

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Tetanus

Introduction Although the clinical picture of tetanus has been known for thousands of years its causative agent for about sixty years and almost perfect methods of prophylaxis are known and being practiced the disease remains as one of the most dangerous complications of wounds Intensive studies on the pathogenesis of the disease during the past two decades have served to modify our concepts of the condition and have favored an improved therapeutic approach. Th- discovery that penicillin is an efficient antibiotic for the *Cl tetani in vivo* the effectiveness of this and other antibiotics in the prevention of secondary pulmonary complications the advent of relatively nontoxic muscle relaxants and the realization that with tetanus we deal mainly with a respiratory problem which should be treated as such has led to a marked reduction in the mortality rate

Etiology and Pathogenesis. The *Clostridium tetani* is a large, motile spore forming gram-positive bacillus It is an obligate anaerobe easily cultivated in thyoglycolate and cooked meat media The organism can survive in nature for many years if protected from direct sunlight. The tetanus spores can be found in most samples of soil contaminated with human or animal excreta.

The *Cl tetani* gain entrance to human tissues through contamination of wounds only rarely by other means Puncture wounds lacerations abrasions, ulcerations incised wounds, hypodermic injections anal fissures, carious teeth, abscesses burns human or animal bites contaminated catgut surgical wounds otitis media chiggers, a ruptured viscus gunshot wounds frost bites abortions bed sores umbilical stumps etc. Since the causative agent can be cultured from almost any contaminated wound protective measures are indicated in every instance irrespective of the inoffensiveness of the lesion.

The multiplication of the *Cl tetani in vivo* is governed, among other factors, by the presence of necrotic tissue pyogenic organisms and small amounts of calcium salts that lower oxidation-reduction potential of tissue The bacillus is not invasive and frequently the infection remains localized in a small area. Once the organisms start to grow a toxin is produced which can by itself accelerate their multiplication with increased production of toxin.

The disease results from production of this powerful exotoxin One milligram of the purified and crystallized tetanus toxin contains 6 400 000 lethal mouse dosages so that its toxic potency is second only to that of *Clostridium botulinum* Fixation of a certain amount

of this powerful toxin by the cells of the central nervous system leads to very serious clinical manifestations and even to death. The toxin may act in the neuromuscular end organs, producing sustained muscle spasms, and on the motor nerve cells of the spinal cord, medulla, and pons, causing convulsions. Once the toxin is fixed and changed by the cells of the central nervous system it cannot be neutralized by any amount of antitoxin There is enough experimental proof to suggest that the toxin is carried to the cells of the central nervous system through the circulating blood

Clinical Picture: The incubation period may vary from two days to several months usually from two to fifteen days The manifestations may be limited to a persistent rigidity of a group of muscles around the portal of entry which may last for months (localized tetanus) This is the least fatal of all forms of tetanus

The symptoms and signs of generalized tetanus supervene from fixation of variable amounts of toxin by the cells of the central nervous system. A specially serious form of generalized tetanus (cephalic tetanus) results from lesions in the head and neck Occasionally mild cases occur in which there is only moderate muscular rigidity without tetanic seizures

In some cases the prodromata are characterized by restlessness, irritability headache profuse perspiration and generalized body aches and pains In others there is a rapid development of muscular rigidity with stiffness of the jaw neck, back, and abdominal muscles Among the first affected muscles are those innervated by the fifth, seventh, ninth, tenth, eleventh, and twelfth cranial nerves With the appearance of the full clinical picture of the disease, sustained spasm of the muscles of mastication leads to trismus With contraction of the facial muscles and involuntary raising of the eyebrows, the distorted grin known as "risus sardonicus" supervenes Dysphagia results from contraction of the pharyngeal muscles Stiffness of the neck, chest, back, abdominal and limb muscles leads to a state of generalized spasticity The patient is in extreme pain during convulsions, and is unable to cry because of the vise like contractions of the chest muscles Opisthotonus results from sustained spasm of the back muscles.

The patient has a clear sensorium is perfectly conscious of his surroundings, and in severe anxiety There is profuse perspiration, and cyanosis may appear as a result of hypoxemia from ineffective breathing and frequent spasms of the laryngeal muscles. Although low grade fever is the rule in tetanus high fever is indicative of overwhelming toxemia or pulmonary bacterial complications Neurological examination reveals generalized deep tendon hyperreflexia, and often, sustained clonus There are no sensory changes.

The laboratory is of little assistance in the diagnosis of tetanus Not infrequently the causative organism can be isolated from the local lesion if pus or infected tissue is used for cultures Leukocytosis is a sign of complicating lung disease The spinal fluid, although under increased pressure is otherwise negative The urine as a rule is normal.

Some of the milder cases may recover spontaneously without treatment. However in the severe case the symptoms and signs will continue unabated and with increasing intensity until death, three to fifteen days after onset. Noises, hypodermic injections, or any other

stimuli irrespective of their mildness may precipitate generalized tonic convulsions and severe prolonged, and sustained laryngeal spasms which could lead to death from asphyxia If the patient survives, the muscular rigidity may persist for over a month, and convalescence is prolonged.

Complications The most dreaded complications of tetanus are (1) Paralysis of the respiratory center (2) paralysis of the muscles of respiration (3) sustained laryngeal spasms (4) bronchial obstruction by secretions from the upper respiratory passages leading to atelectasis, and hypoxemia with hypoxia of the respiratory center (5) aspiration pneumonia (6) overwhelming toxemia (7) dehydration and disturbance of electrolyte balance (8) serum sickness (9) intercurrent nonpulmonary infections (10) decubitus ulcers (11) muscular contractures (12) malnutrition (13) fecal impaction (14) urinary retention and cystitis, and (15) compression fractures of vertebrae due to convulsive seizures

It is evident that the disease is mainly a respiratory problem, and that prevention and treatment of pulmonary complications are the most important objectives in its management.

Differential Diagnosis. Generalized tetanus is rarely a diagnostic problem. The clinical picture of strychnine poisoning with opisthotonus generalized muscle spasms, "risus sardonicus," and tonic convulsions may closely resemble tetanus. However the muscles are relaxed between seizures in strychnine poisoning in contrast with the constant rigidity in tetanus. In rabies the history of a dog bite the drooling of saliva, spasms of the muscles of deglutition fever anxiety excitement, delirium, hyperesthesia, and the nature of the convulsions (tonic and clonic), serve as important differential points. Other conditions in which trismus occurs such as serum sickness and peritonsillar abscess, may be considered in the differential diagnosis The normal spinal fluid in tetanus eliminates the possibility of meningitis.

Treatment The most important objectives in the management of tetanus are (1) Neutralization of the free toxin with tetanus antitoxin (2) elimination of the source of toxin by debridement of all accessible portals of entry or by administration of antibiotics (3) prevention of convulsions and severe muscle spasms by use of anesthetics and muscle relaxants (4) environmental and pharmacological sedation (5) maintenance of efficient hydration and electrolyte balance (6) maintenance of proper nutrition, and (7) prevention and treatment of pulmonary complications through maintenance of unobstructed air passages by mechanical means and by administration of antibiotics

Neutralization of the Free Toxin It is generally recognized that the local and general symptoms of tetanus are caused by toxemia, at times overwhelming, which occurs when multiplication of *Cl tetani* is rapid or prolonged In those circumstances there is marked diffusion of toxin and massive fixation by the cells of the central nervous system The most important therapeutic aims therefore are neutralization of the free toxin and detention of its production.

Most observers agree that 50 000 units of tetanus antitoxin intravenously is a dose large enough to neutralize all the unfixed and free toxin in any patient with a chance of recovery Since it is impossible to ascertain whether fixation

of the toxin by the cells of the central nervous system is progressing, and since symptoms may arise from fixation of a sublethal dose of toxin, it is advisable to administer 10 000 units of antitoxin intramuscularly for the first four or five days. This prevents fixation by the cells of the central nervous system of a dose sufficiently large to be fatal. The intra thecal administration of antitoxin although of great benefit, is impractical since general anesthesia or heavy doses of muscle relaxants are required in the majority of severe cases of tetanus presenting frequent convulsions and opisthotonus Besides, tetanus antitoxin may lead to untoward reactions when given by this route

Elimination of the Source of Toxin The neutralization of the free toxin does not eliminate the possibility of further production, and treatment with repeated daily injections of antitoxin is not always safe The ideal procedure would be to eradicate the source of toxin This can be done in some instances by wide excision of the portal of entry when accessible Not all portals of entry however are easily accessible Some remain undiscovered. Many would require major surgical intervention as in endometritis extensive chronic ulcers or lacerations large abscesses resulting from intramuscular injections a ruptured viscus, osteomyelitis etc In still other cases, numerous lesions are suspected, but the one responsible for the growth of *Cl tetani* cannot be localized with ease Besides, debridement *per se* does not eliminate the infection in every case

In every accessible portal of entry not requiring a major surgical procedure, debridement should be tried as an adjuvant in treatment. The tissues around the portal of entry should be infiltrated with 10 000 units of tetanus antitoxin, and after one hour excision of all the necrotic tissue is advisable The antitoxin will neutralize the toxin in the lesion and around it, thus preventing its diffusion or dissemination during debridement. Removal of necrotic tissue will reduce the multiplication of *Cl tetani* and exposure of the lesion to air may help in altering the metabolism of the bacillus, since it is an anaerobic saprophyte.

However it has been demonstrated that penicillin is a powerful antibiotic against *Cl. tetani* and eradication of the infection can be attained, in the majority of instances, within twenty-four hours after the initiation of therapy with 30 000 units intramuscularly every three hours or with a single daily dose of 400 000 units of procaine penicillin The local use of this antibiotic has also been recommended in lesions with poor blood supply

Muscle Relaxation The attainment of muscular relaxation in tetanus simplifies some of the main objectives in its management. The control of frequent laryngeal spasms will prevent death from asphyxia. Relaxation of the chest muscles will improve breathing, increase oxygen and carbon dioxide ex change, and elevate blood oxygen saturation, thus minimizing the dangers of hypoxemia and hypoxia of the respiratory center Unobstructed air passages will aid cough and expectoration, reducing the danger of bacterial pulmonary complications or fatal bronchial obstruction. The correction of dysphagia reduces the dangers of dehydration malnutrition, and disturbances of electrolyte balance Nutrition through the stomach tube will then be feasible, since there will be no danger of a continuous stimulus from pressure in the pharynx

with resulting laryngeal spasms and asphyxia. The aspiration of secretions from the upper respiratory passages, so commonly observed among tetanus cases fed by this method, will be prevented. Tracheotomy with removal of bronchial secretions, and the use of a respirator in case of respiratory paralysis will be simplified. More complete sedation will be obtained since it is ineffective in the presence of convulsions even when massive doses of barbiturates or chloral hydrate are administered. Moreover the elimination of convulsions or constant muscle spasms will prevent death from exhaustion in the overwhelmingly toxic patients, and in those with anemia, malnutrition, intercurrent infections, and pulmonary or heart disease.

An ideal muscle relaxant in tetanus should be nontoxic, of lasting effects and easy to administer. The use of d-tubocurarine hydrochloride has been condemned because of its transitory and unpredictable effects, and the always present danger of severe respiratory depression and bronchial obstruction. The use of intravenous pentothal sodium is not practical because of transitory beneficial effects and the danger of respiratory depression. Other drugs are either too toxic or of very fleeting effects.

Rectal tribromoethanol (avertin) in doses of 50 mg. per kilogram of body weight every three to four hours has been found effective by some investigators but may cause respiratory depression and rectal irritation. Mephenesin has been found beneficial when intravenously or orally administered. Toxic reactions, such as sudden fall in blood pressure from a direct myocardial depression, hemolysis occasionally accompanied by hemoglobinuria, abdominal pain, thrombophlebitis and anemia, have been reported. Its administration in elixir or powder form has been condemned except when given by stomach tube because its anesthetic effects in the buccal and pharyngeal mucosa increases the dangers of aspiration not only of the drug, but of the secretions of the upper respiratory passages.

Although the ideal muscle relaxant is still lacking, intravenous nephenesin appears to be the drug of choice in mild or moderately severe tetanus when convulsions are mild or infrequent. The intravenous administration of 50 cc. of a two per cent solution every four hours may lead to almost complete muscular relaxation. If given diluted in 500 cc. of five per cent dextrose in water at a rate of sixty drops per minute the muscle relaxation may be prolonged. The drug has time limitations in the severe form of tetanus when convulsions are frequent and severe requiring continuous injections, or when the disease is accompanied by serious cardiovascular ailments.

Environmental and Pharmacological Sedation. The treatment of convulsions is always a major problem in tetanus. A quiet environment, a dark peaceful well aereated room, free of drafts, and devoid of excessive furniture is most beneficial. Efficient, constant nursing care is necessary. Phenobarbital sodium in intramuscular doses of 0.13 Gm. (2 grains) every two or three hours is beneficial. Other drugs have been used to moderate advantage however complete sedation is unobtainable without muscle relaxation.

Hydration, Electrolyte Balance, Nutrition. The patient with tetanus loses great amounts of water and sodium chloride by perspiration and respiration. This coupled with dysphagia leads, in severe cases, to extreme dehy

dration. Although it is not always possible to measure the fluid and electrolyte requirements in every case of tetanus the daily intravenous administration of 1000 to 2000 cc (1 to 2 quarts) of isotonic sodium chloride solution will prevent clinical signs of dehydration and acidosis in most cases The extreme restlessness convulsions fever and overwhelming toxemia observed in severe cases lead to an increased body metabolism with a corresponding increase in caloric requirements In many instances the addition of five per cent dextrose to the intravenous fluids suffices, but markedly debilitated patients may require feeding by stomach tube The feedings should consist of substances yielding readily usable calories such as carbohydrates Easily digestible proteins should be included in an attempt to maintain a positive nitrogen balance Plasma and aminoacids should be administered intravenously to those patients with severe malnutrition.

It must be reemphasized that the constant pressure of the stomach tube in the nasopharynx may increase the frequency and severity of convulsions provoke severe and prolonged laryngeal spasms, and lead to overproduction and aspiration of secretions all of which might result in pulmonary complications Therefore, its use should be limited to those patients in whom muscle relaxation is attained.

Prevention and Treatment of Pulmonary Complications The prevention of pulmonary complications is mainly a mechanical problem Since the cough reflex is depressed, the respiratory excursions decreased, heavy sedation increases the likelihood of aspiration of secretions from the upper respiratory tract. The respiratory pathways can be maintained patent by frequent suction, raising the foot of the bed for drainage, and by tracheotomy Removal of bronchial secretions may prevent death from asphyxia or aspiration pneumonia.

Tracheotomy should be resorted to at the first sign of recurrent spasms of the thoracic and laryngeal muscles or generalized convulsions This procedure, preferably done under pentothal sodium, avertin, or under local anesthesia when muscle relaxation is obtainable will permit bypassing of the secretions of the mouth, pharynx, and larynx it will neutralize the effects of the laryngeal spasms and will permit direct removal of secretions already aspirated into the trachea and bronchi It will also allow direct flow of oxygen into the lungs through the tracheal tube bypassing the obstruction caused by laryngeal spasms and will render the use of a respirator more practical in case of impending respiratory paralysis

Penicillin is useful in the prevention of bacterial pulmonary complications and is curative in others Together with streptomycin in daily intramuscular 1 Gm doses it aids in the control and cure of aspiration pneumonia. The development of pneumonia during penicillin therapy in the course of tetanus is an indication for the use of any of the newer antibiotics

Prophylaxis. The most important objectives in the prophylaxis of tetanus are (1) adequate management of contaminated wounds by thorough and prompt debridement and antibiotic therapy (2) passive, and (3) active immunization. It must be emphasized that passive immunization should be instituted in any wound, no matter how trivial, if conditions appear to favor infection with *Cl tetani*

The immediate passive protection is

attained by the administration of 1500 to 10 000 units of tetanus antitoxin parenterally after a negative dermal test for sensitivity to horse serum The dose should depend on the nature extent, and degree of contamination of the lesion It must be emphasized that 1500 units of tetanus antitoxin may not be protective even in the most trivial lesions The antitoxin serves to neutralize the free toxin, but it does not possess either bactericidal or bacteriostatic effect on the *Cl tetani* Although great success has been attained with serum prophylaxis there are great disadvantages to its use It renders protection for only a week or two and a significant number of patients become sensitized to horse serum Serum sickness or anaphylactic shock may supervene with subsequent doses endangering the patient's life.

Prophylaxis by active immunization is most satisfactory Initial immunization is achieved by the parenteral administration of two doses of an alum-precipitated toxoid, or three doses of fluid toxoid at monthly intervals A booster dose is given after one year and thereafter at two- or three-year intervals. The immunity attained by the administration of toxoid develops very slowly and is not protective when begun at the time of injury However if the patient has previously received toxoid in proper doses, a protective antibody response will supervene after a booster dose The value of active immunization is exemplified by the extreme rarity of tetanus among the United States Armed Forces during World War II

Prognosis The most important factors governing the issue of life or death in tetanus are (1) The incubation period (2) the interval between the onset of trismus and appearance of convulsions or severe muscle spasms (3) the patient's age, (4) the promptness of treatment (5) the general state of health at onset (6) the type and location of the portal of entry (7) complications (mainly pulmonary) (8) the frequency of convulsions and laryngeal spasms and (9) the approach to the case

A short incubation period and a *short interval between onset of trismus* and convulsions indicate extensive production and a rapid diffusion and fixation of toxin by the cells of the central nervous system These are, perhaps, the most important considerations for a prompt and heroic treatment with all available measures

Advanced age is always a sign of poor prognosis in tetanus, especially when accompanied by degenerative diseases of the heart and/or lungs It must be emphasized that the great majority of deaths are recorded after the age of fifty However if treatment is instituted early the chances of recovery are increased

Although the prognosis of tetanus is always poor the idea that death is inevitable in the most severe cases is being revised. A more optimistic view is now entertained Being mainly a respiratory problem tetanus should be managed by a team of specialists and not by the internist or surgeon, alone With full cooperation of the general surgeon, the anesthetist, and the otolaryngologist, the patient with tetanus has a more certain chance of survival.

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SECTION VI

EMERGENCIES OF THE VASCULAR SYSTEM

47

Acute Axillary Vein Thrombosis

THROMBOPHLEBITIS of the axillary vein is rarely seen On various occasions it has been termed primary axillary vein thrombosis, effort thrombosis primary phlebitis, or effort phlebitis of the axillary vein. The occurrence of thrombophlebitis in the axillary vein is such a rarity that its cause has not been definitely established. Well-developed men are the usual victims of this type of phlebitis The onset of the thrombosis can be traced to strenuous effort of the arm most frequently used sudden exertion or unusual exercise may be the precipitating cause

Several theories have been advanced as to the cause of this particular type of thrombophlebitis It was originally believed that a localized phlebitis secondary to the sudden trauma of compression or stretching was the major factor Some investigators have postulated an anatomic cause Venous constriction by the costocoracoid ligament producing a disruption of one of the axillary vein valves by sudden effort has been indicated as an exciting factor This disruption initiates the inevitable thrombosis [1] The site of constriction lies below the humeral head which strikes against the subscapularis during abduction of the arm.

Infection itself is not the cause of this type of phlebitis Many years ago spasm of the vein due to sympathetic irritation as the result of trauma was suggested as the major initiating factor [2] In view of our present knowledge of reflex sympathetic dystrophy the basic etiology of this type of thrombosis perhaps may be elucidated on this basis.[3]

The pathology in the vein itself has been demonstrated to be a true thrombosis. One investigator at operation found no thrombosis present, only marked venous spasm.[2] However clinical and radiologic studies of the axillary vein in patients with this syndrome have revealed true thrombosis

The symptomatology of primary axillary thromboplebitis follows a similar pattern in all cases A history of a prolonged use of the arm, sudden exertion, or the maintenance of one position for a long period of time is usual. This is followed by the appearance of sudden, painless swelling of the entire arm without a systemic reaction. No local inflammatory signs are noted. Initially the arm is cyanotic and shows clinical evidence of edema The axillary vein may be palpated readily and is tender and firm. As the disease enters the subacute phase a collateral circulation develops With this collateral circulation the superficial veins of the arm become prominent and the cyanotic hue disappears with the appearance of a dusky

redness to the skin The edema subsides as the disease progresses to the chronic phase However the circumference of the affected arm remains greater than the normal extremity This residual disparity is the rule rather than the exception

Treatment Treatment of axillary thrombophlebitis as in many other vascular diseases is divided into conservative (medical) or operative (surgical) procedures Medical measures are usually the first to be initiated. This regimen may include rest, elevation of the arm, and the application of an Ace bandage A light Unna paste cast may be effective in some cases Conservative treatment has the primary objective of reducing and/or preventing additional edema. Experience with heparin and dicumarol has not been great in this type of thrombophlebitis

Surgical measures may be necessary in certain instances In severe cases incisions have been made in the arm to permit the escape of edematous fluid (similar to the Kondoleon operation) Resection of the involved venous segment with or without periarterial sympathectomy has been advocated [2]

In view of the increasing knowledge of the sympathetic nervous system paravertebral block obviates the need for operative resection of the venous segment. Nerve block to include the stellate ganglion has been an effective method of treatment. The beneficial results may be attributed to the same factors producing the benefits of lumbar paravertebral block in the treatment of thrombophlebitis in the lower extremities

The technic is not difficult to follow A cervicothoracic injection may be accomplished either by the anterior or the posterior route The most popular of these procedures is the posterior The patient is placed on his side with the head flexed and elevated on a pillow to prevent lateral compressure of the cervical spine Wheals are raised 4 cm (1⅗ inch) lateral to the spinous process of the seventh cervical and first, second and third thoracic vertebrae These wheals are placed opposite the lower border of the first four ribs Needles are then introduced perpendicular to the skin for about 5 cm (2 inches) At this distance the rib or transverse process will be encountered The needle is then passed under the lower edge of the rib and pushed in a downward direction at an angle of twenty degrees toward the midline until the lateral aspect of the vertebra is reached Before injection, aspiration should be carried out to determine whether or not a vessel or the pleura has been pierced Ten cc of 0.5 per cent novocain are injected at each site In view of the fact that the stellate ganglion lies in a groove in the neck of the first rib in front of the first thoracic nerve a Horner s syndrome often results although the block may be successful without the development of this syndrome Increased warmth on the side of the injection is one of the signs indicating a successful block.

Prognosis With adequate treatment which includes paravertebral sympathetic block, the prognosis as to the return of functional activity is good in axillary thrombosis The arm may not completely return to its normal physiologic capabilities in comparison to the capabilities of the other extremity

In acute axillary thrombophlebitis, no serious complication such as embolism, has been reported A reduction in the

swelling and the return of function occurs with several paravertebral sympathetic blocks

When the chronic stage has developed without the benefit of early treatment the outlook is less favorable Weakness and stiffness become residual disabilities in spite of treatment Exertion of any type initiates a recurrence of edema without pain

When the disease has had a chronic nontreated course, the skin of the affected arm continues to have a dusky red color At this stage paravertebral block has a transitory beneficial effect, and a unilateral thoracic sympathectomy may be contemplated Sympathectomy should be advised only when a demonstrable beneficial effect has been noted following paravertebral novocain block

When conservative measures fail and nonoperative procedures are ineffectual it may become necessary to undertake operative methods for the removal of an axillary vein thrombus Surgical procedures for embolectomy etc are discussed in the next chapter

Recent reports have indicated that axillary vein thrombus may occur following blood transfusions.

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Venous Thrombosis and Arterial Embolism

VENOUS THROMBOSIS

Introduction Thrombus formation in the deep veins of the lower extremity is a serious complication of any illness and one that is a threat to the life of the patient. The ideal in the treatment of this complication is prevention. However if prophylaxis fails, the early recognition of the presence of a deep venous thrombosis and the initiation of immediate and adequate treatment is of primary importance In this presentation a method of management which has proved satisfactory is described.

Classification When a thrombus forms in the deep veins of the lower extremities it is classified generally into two forms, phlebothrombosis and thrombophlebitis, a terminology suggested by Ochsner and De Bakey[9,10]

Phlebothrombosis, or "bland" thrombus,* refers to a thrombus that is either nonadherent or very loosely attached to the intima and without any associated inflammatory reaction Accordingly thromboembolism is always imminent

The term thrombophlebitis is used to indicate the presence of an inflammatory reaction in association with the thrombosis In this type, the thrombus is of the adherent variety and the danger of thromboembolism is remote

The concept that phlebothrombosis and thrombophlebitis are different and distinct is believed open to question. It is the opinion of the author that the pathogenesis for each is the same, but the difference in the clinical manifestations is dependent upon the rate of formation and the extent of the thrombus rather than upon the presence or absence of an associated inflammatory reaction. In thrombophlebitis it is believed that the thrombus is extensive and the rate of its formation and propagation is rapid. Conversely in phlebothrombosis the extent of the thrombus is limited and the rapidity of its formation and propagation is retarded. This concept is based on observations, repeatedly made, of patients in whom the first indication of the presence of a deep venous thrombosis was the occurrence of either a fatal or nonfatal pulmonary embolism In many of the patients in whom the embolus was not fatal the first indication of its site of origin was the occurrence of pain and swelling in one of the lower extremities seven to ten days later The end result in the affected extremity was not unlike that present in patients with thrombophlebitis

Etiology The exact etiologic factor or factors in the formation of a venous thrombosis in the deep veins of the legs is unknown Consequently many pos

tulates have been proposed, a discussion of which is beyond the scope of this presentation However there are certain predisposing causes for the formation of a deep venous thrombus that may be enumerated. These are (1) operation (2) parturition (3) trauma and (4) prolonged confinement in bed, particularly in the treatment of patients with heart disease In addition there are basic contributory factors that are commonly associated with the predisposing causes These are (1) circulatory stasis (2) trauma (3) hemorrhage (4) shock, (5) infection (6) malnutrition (7) anemia and (8) dehydration Contrariwise, there are patients in whom venous thrombosis occurs without any evident predisposing or contributory cause Such occurrences serve only to emphasize our lack of knowledge relative to specific etiologic factors

Stasis in the peripheral venous circulation is considered one of the most, if not the most, important factor in the formation of a thrombus within a vein. The return of the venous circulation to the right side of the heart is dependent upon five factors (1) The *vis a tergo* or the force of the heart beat (2) the contraction of the muscles in the extremities (3) the aspiration action of the thorax (4) the viscosity of the blood and (5) the effect of gravity Disturbances in one or more of these factors that may induce stasis in the venous circulation and predispose to the formation of a deep venous thrombus are commonly present in heart disease, malnutrition, hemorrhage, shock, trauma, dehydration, the improper positioning of the patient in bed, and finally the use of constricting dressings.

When one considers the above, it is difficult to explain why in patients with a paraplegia of the lower extremities and infected decubitus ulcers, deep venous thrombosis and pulmonary embolism are comparatively infrequent complications

Symptoms The symptoms that are related to the presence of a deep venous thrombus in one of the extremities vary from patient to patient. However when one analyzes carefully the case histories, the patients may be divided into four group patterns or categories, according to the symptoms that are manifest.

GROUP I—OBJECTIVE SYMPTOMS PRESENT, SUBJECTIVE SYMPTOMS MINIMAL OR ABSENT The patients in this group have slight or no subjective symptoms However on examination of the extremities there may be noted (1) Tenderness along the plantar surface of the feet, (2) pain in the calf on dorsiflexion of the feet (Homans sign) (3) tenderness on compression of the calf and on palpation a feeling of fulness or "heaviness" of the calf (4) duskiness of the toes and distention of the superficial veins (satellite veins of Pratt) on dependency (5) swelling of the ankle or leg The diagnosis in patients in this group is dependent upon daily and often repeated examinations of the lower extremities Pulmonary embolism, though not an initial manifestation may occur as a complication

GROUP II—SUBJECTIVE AND OBJECTIVE SYMPTOMS PRESENT In the patients in this group the initial complaint is pain in the calf. On examination of the affected extremity the objective symptoms may include one or more of those previously described. In this group similarly as in Group I pulmonary embolism may occur as a complication of the venous thrombosis.

GROUP III—PRIMARY SYMPTOMS, PULMONARY IN ORIGIN SUBJECTIVE AND OBJECTIVE SYMPTOMS SLIGHT TO MODERATE OR ABSENT Usually the

initial symptom in patients of this group is chest pain Dyspnea cough and hemoptysis either singly or combined may be present. All too frequently the primary diagnosis is pneumonia particularly virus pneumonia Concomitant with the pulmonary symptoms objective evidence of a venous thrombosis may be present However these objective symptoms may not be in evidence for seven to ten days

GROUP IV—ACUTE THROMBOPHLEBITIS AND ACUTE FULMINATING THROMBOPHLEBITIS (PHLEGMASIA CERULEA DOLENS) In patients who comprise this group the venous thrombus is extensive and forms rapidly It is frequently called the adherent or inflammatory type of thrombosis relative to which the complication of thromboembolism is considered less likely to occur Dependent upon the character and the severity of the symptoms there are two clinical types of thrombophlebitis

Type I—Acute Thrombophlebitis Thus is the type most commonly observed It is characterized usually by moderately severe pain in the affected extremity commonly the left, by fever (102° to 104 F [38 9° to 40 C]) and frequently chills On examination of the extremity diffuse swelling "heaviness" tenderness dusky hyperemia, and an increase in the skin temperature are noted. A diminution in the femoral arterial pulsation is generally observed

Type II—Acute Fulminating Thrombophlebitis (Phlegmasia Cerulea Dolens). In this type the local and systemic reactions of the patient to the disease process are more acute and more severe Shock is not infrequently present and death may occur within thirty-six to forty-eight hours Chills are frequent and the fever is high (104 to 106 F [40 to 41 1 C]) The involved extremity is massively swollen and tender The swelling may extend to the area of the sacrum the lower portion of the abdomen and to the opposite extremity A cyanotic rubor with diffuse petechial hemorrhages is commonly present The massive swelling of the extremity and the associated reflex arterial spasm may be sufficient to occlude completely the peripheral arterial pulsation and simulate an embolic occlusion (pseudo-embolic thrombophlebitis) In fact, an ischemic necrosis of a varying degree may occur and require a minor or major amputation of a part Furthermore even though the inflammatory reaction associated with the venous thrombosis is severe pulmonary thromboembolism may and does occur Indeed, in some patients such a complication has been the immediate cause of death

Diagnosis The diagnosis of a deep venous thrombosis in one of the extremities is frequently a simple one but in some patients it may prove most difficult. However if one considers the possibility of its presence a careful examination of the extremities daily and even twice daily may aid in the making of an early diagnosis

Allen[1] has emphasized repeatedly the significance of a concomitant rise in temperature pulse and respiration as an early manifestation of an occult venous thrombosis. In fact, when such occurs prophylactic ligation of the superficial femoral vein bilaterally is advised[1] Pain and tenderness involving the plantar surface of the foot, pain referred to the calf on dorsiflexion of the foot (Homans sign) a dusky rubor of the toes, and distention of the superficial veins (sentinel veins of Pratt) on dependency are all indicative of a deep venous thrombosis in an extremity In addition palpation of the calf will demonstrate

frequently a local increase in the skin temperature, tenderness, and a concomitant "heaviness" in the tissues, with a diminution in the normal flabby consistency

The occurrence of a pulmonary infarction postoperatively is usually *prima facie* evidence of a nonadherent or loosely adherent venous thrombus Unfortunately and all too frequently this primary manifestation of a deep venous thrombosis may be the immediate cause of death of the patient. In patients with mitral valvular disease and/or congestive failure in whom a pulmonary infarct occurs one should consider always the possibility of a stasis infarction within the pulmonary circulation rather than a thromboembolism originating in a deep thrombosis in one of the lower extremities.

A thrombus in the superficial or saphenous vein, particularly if it is not a varicose vein may be indicative of a primary thrombosis in the deep veins It is believed that in these instances in which a thromboembolism is associated with a venous thrombosis in the superficial system the true origin of the embolus is most commonly an unrecognized deep venous thrombosis in the same or in the opposite extremity

TREATMENT

In the treatment of patients in whom a deep venous thrombosis in one of the extremities is present, rigid individualization is practiced. However there are certain basic principles of prophylaxis which are believed important and generally applicable. Accordingly a discussion of both the prophylactic and definitive methods in treatment is presented.

Prophylactic Treatment Prophylactic measures may be used in the preoperative preparation, during the operation, and in the postoperative care of the surgical patient.

PREOPERATIVE PREPARATION Every patient on whom an elective operation is planned should be screened carefully Dehydration and increased viscosity of the blood, predisposing factors to venous thrombosis, should be corrected by adequate fluid and electrolyte replacement. Similarly an anemia or nutritional and metabolic disturbances should be treated adequately so that the patient is in the best condition possible for the operation that is contemplated. If varicose veins are present, elastic bandage supports should be prescribed or a preliminary corrective operation done, depending upon the exigencies of the individual case

SAFEGUARDS DURING THE OPERATION It is firmly believed that the incidence of a deep venous thrombosis as a postoperative complication will be lessened if undue trauma to tissues is avoided. This may be accomplished by a strict adherence to the tenets of Halsted. These tenets embody (1) absolute hemostasis (2) gentleness and care in the handling of tissues (3) the use of fine sutures and ligatures, preferably silk (4) the avoidance of mass ligatures and the unnecessary strangulation of tissues In any operation and particularly in those that are prolonged and require a radical resection of large areas of tissue shock may occur The prevention of shock by the maintenance of an adequate fluid and blood volume is essential. This is best accomplished by the continuous and adequate replacement of blood loss by transfusions of whole blood either intravenously intra arterially or both.

POSTOPERATIVE CARE OF THE PATIENT The prevention of circulatory

stasis is believed to be one of the most important factors in the prophylaxis of venous thrombosis Although it is stressed relative to the postoperative care of the patient, it is just as important in the preoperative period of preparation and during the operation. If stasis of the circulation is to be prevented one must (1) maintain an adequate circulating blood volume (2) provide for an uninhibited respiratory exchange and an adequate pulmonary ventilation (3) induce the patient to exercise actively the leg muscles soon after operation (4) change the position of the patient frequently (5) avoid flexed positions of the knee and hip joints and dressings that constrict (6) use the Trendelenburg position where indicated as an aid to the return flow of blood to the heart Although early ambulation may not lower the incidence of deep venous thrombosis it should be practiced, provided it does not prove an added strain and inconvenience to the patient. The use of anticoagulants and/or ligation of the superficial femoral vein bilaterally as a prophylaxis for deep venous thrombosis is neither practiced nor recommended

Definitive Treatment In the discussion of symptoms the patients were classified into four groups according to the clinical manifestations that were present. In discussing treatment the same group classification is used

GROUP I—*OBJECTIVE* SYMPTOMS PRESENT SUBJECTIVE SYMPTOMS MINIMAL OR ABSENT The treatment of patients in this group is conservative Initially absolute bed rest is prescribed and the affected extremity is elevated on a pillow The anticoagulant, heparin is administered intermittently by the intravenous route When used in this manner daily determinations of the bleeding and coagulation times are not required The anticoagulant is administered for nine days in a gradual decreasing dosage The first three days the daily dosage of heparin is 150 mg (15 cc.) 100 mg (10 cc) and 150 mg (15 cc) given at intervals of eight hours (7 00 A.M., 3 00 P M., and 11 00 P M) The second three days the daily dosage is decreased to 100 mg (10 cc) 75 mg. (7 5 cc.) and 100 mg (10 cc.) During the last three days it is further decreased to 75 mg (7.5 cc) 50 mg (5 cc.) and 75 mg (7.5 cc) The administration of heparin in smaller doses (50 mg) and at more frequent intervals (four hours) is preferred by many However the previously described method of administration has proved satisfactory

Dicumarol is an anticoagulant that is in popular use. The absolute necessity for a completely reliable laboratory and the variation in the patient response of the prothrombin time to a specific dose of the drug are objections to its use The low cost of dicumarol is nullified by the added expense of the daily laboratory determinations that are required The author has had no experience with the newer anticoagulant tromexan and cannot comment on its value

Penicillin (300 000 units) is administered intramuscularly at intervals of twelve hours It has been a common observation that the response of the patient to the combined use of the antibiotic and the anticoagulant is greater than when the anticoagulant alone is used.

On the second day of treatment active use of the leg muscles is encouraged by prescribed exercises The morning of the third day and daily thereafter an elastic bandage (A C E.) support is applied firmly from the base of the toes to the tibial tubercle and the patient is

allowed to walk. Early ambulation prevents atrophy of the leg muscles improves the return flow of blood, stimulates the formation of a compensatory collateral venous circulation, and inhibits the propagation of a venous thrombus

Allen[1] has championed strongly the ligation of the superficial femoral vein bilaterally as the primary treatment of choice, particularly as a prophylaxis for thromboembolism Admittedly a pulmonary infarct is an ever present danger However the disadvantages inherent in the routine practice of superficial femoral vein ligation are believed to exceed the proclaimed advantages Should a pulmonary embolus occur as a complication while the patient is being treated conservatively ligation of the inferior vena cava rather than ligation of the superficial femoral vein bilaterally is preferred.

Group II—Subjective and Objective Symptoms Present The treatment for the patients that comprise this group is the same as that prescribed for the patients in Group I

Group III—Primary Symptoms, Pulmonary in Origin Subjective and Objective Symptoms Slight to Moderate or Absent In this group the initial symptom of the patient, and frequently the first evidence of a deep venous thrombosis, is the occurrence of a pulmonary infarct. This may or may not be fatal. In other patients in this group symptoms and signs of a deep venous thrombosis in one of the extremities may be present at the time the pulmonary infarction occurs In any event, if the pulmonary infarction is nonfatal, the main goal of treatment is the prevention of recurrent thromboembolism. Accordingly the treatment of choice is ligation of the inferior vena cava, regardless of the paucity or severity of the clinical manifestations in the affected extremity It is true that some of the patients in this group may respond to anticoagulant therapy or ligation of the superficial femoral vein. If either type

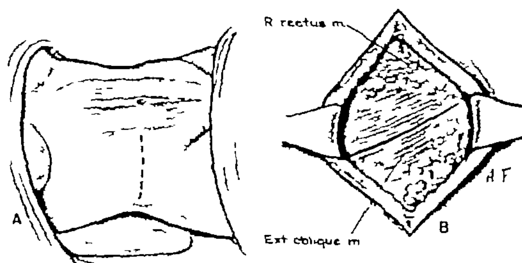


Fig 1 A. The patient is in the supine position and the right side is elevated on a sand bag to a 25 angle with the horizontal. The outline of the skin incision is shown. B A wide dissection in the subcutaneous tissue plane is done and the wound margins are retracted. The line of separation of the external oblique muscle is depicted.

stasis is believed to be one of the most important factors in the prophylaxis of venous thrombosis Although it is stressed relative to the postoperative care of the patient, it is just as important in the preoperative period of preparation and during the operation. If stasis of the circulation is to be prevented one must (1) maintain an adequate circulating blood volume (2) provide for an uninhibited respiratory exchange and an adequate pulmonary ventilation (3) induce the patient to exercise actively the leg muscles soon after operation (4) change the position of the patient frequently (5) avoid flexed positions of the knee and hip joints and dressings that constrict (6) use the Trendelenburg position where indicated as an aid to the return flow of blood to the heart. Although early ambulation may not lower the incidence of deep venous thrombosis it should be practiced, provided it does not prove an added strain and inconvenience to the patient. The use of anticoagulants and/or ligation of the superficial femoral vein bilaterally as a prophylaxis for deep venous thrombosis is neither practiced nor recommended.

Definitive Treatment In the discussion of symptoms the patients were classified into four groups according to the clinical manifestations that were present. In discussing treatment the same group classification is used.

GROUP I—OBJECTIVE SYMPTOMS PRESENT SUBJECTIVE SYMPTOMS MINIMAL OR ABSENT The treatment of patients in this group is conservative In itially absolute bed rest is prescribed and the affected extremity is elevated on a pillow The anticoagulant, heparin is administered intermittently by the intravenous route When used in this manner daily determinations of the bleeding and coagulation times are not required The anticoagulant is administered for nine days in a gradual decreasing dosage The first three days the daily dosage of heparin is 150 mg (15 cc) 100 mg. (10 cc) and 150 mg. (15 cc.) given at intervals of eight hours (7 00 A.M., 3 00 P.M., and 11 00 P.M) The second three days the daily dosage is decreased to 100 mg (10 cc) 75 mg (7.5 cc) and 100 mg (10 cc) During the last three days it is further decreased to 75 mg (7.5 cc) 50 mg (5 cc) and 75 mg. (7.5 cc) The administration of heparin in smaller doses (50 mg.) and at more frequent intervals (four hours) is preferred by many However the previously described method of administration has proved satisfactory

Dicumarol is an anticoagulant that is in popular use The absolute necessity for a completely reliable laboratory and the variation in the patient response of the prothrombin time to a specific dose of the drug are objections to its use The low cost of dicumarol is nullified by the added expense of the daily laboratory determinations that are required The author has had no experience with the newer anticoagulant, tromexan, and can not comment on its value

Penicillin (300 000 units) is administered intramuscularly at intervals of twelve hours It has been a common observation that the response of the patient to the combined use of the antibiotic and the anticoagulant is greater than when the anticoagulant alone is used.

On the second day of treatment active use of the leg muscles is encouraged by prescribed exercises The morning of the third day and daily thereafter an elastic bandage (A C E.) support is applied firmly from the base of the toes to the tibial tubercle and the patient is

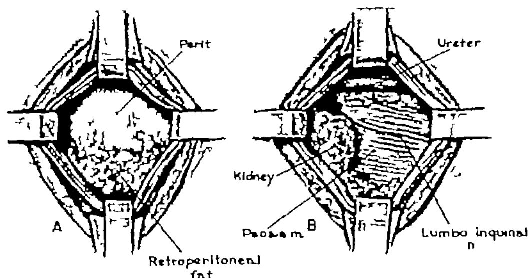


FIG. 3 A. The muscle layers are retracted and a large surface area of the peritoneum and its line of junction with the retroperitoneal fat is exposed. B By digital dissection in the retroperitoneal fat, the peritoneum and the intraperitoneal viscera adjacent are displaced towards the midline, exposing the psoas major muscle, the lower pole of the kidney the lumboinguinal nerve and the ureter

biotic therapy as previously described (5) paravertebral "block" of the lumbar sympathetic ganglia using a solution of procaine hydrochloride (two per cent) The "block" is repeated at eight hour intervals as indicated The usual technic of injection is the deposition of 5 cc. of procaine solution (two per cent) in the paravertebral area at the level of the spinous process of each of the first four lumbar vertebrae a total of 20 cc of the solution being used. However

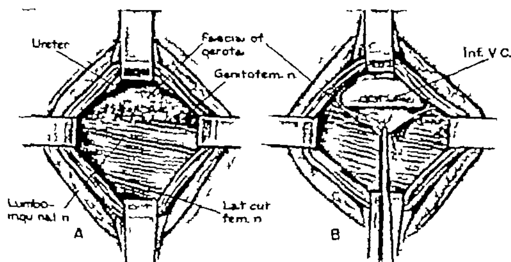


FIG 4 A. The lower pole of the kidney is displaced upward and the ureter is retracted from the surface of the inferior vena cava. The dotted line indicates the site of incision in the fascia of Gerota. B The fascia (Gerota) overlying the inferior vena cava is incised and the inferior vena cava is partially mobilized.

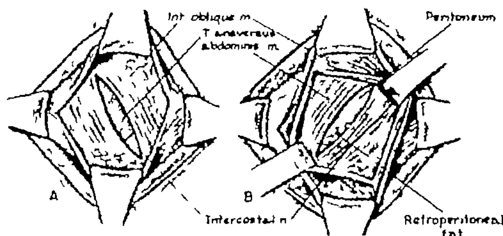


FIG. 2. A. The external oblique muscle is widely retracted and the separation of the internal oblique muscle is shown. Beneath this muscle the fibers of the transversus abdominis and a segment of one of the intercostal nerves are visible. B The internal oblique muscle is retracted, and through the partially separated fibers of the transversus abdominis muscle, the line of junction of the peritoneum and the retroperitoneal fat may be seen.

of treatment is prescribed and while receiving it recurrent nonfatal pulmonary infarction occurs, ligation of the inferior vena cava is advised

The advantages in ligating the inferior vena cava are (1) it is at a sufficiently high level above the thrombus (2) it effects an abundant collateral circulation (3) it interrupts the venous circulation from both extremities at one operation. The technic used in the ligation of the inferior vena cava is depicted in Figs. 1 to 6

The disadvantages in ligating the superficial femoral vein bilaterally are (1) the site of ligation may not be sufficiently high to be safely above the thrombus (2) it is often time consuming and frequently it may be technically difficult (3) the collateral circulation is limited and a persistent disabling swelling of the extremity may occur· (4) a thrombus formed proximal to the level of the ligation may be the origin of a fatal thromboembolism to the lungs.

Shea[11] and his associates have reported generally unsatisfactory late results in patients following ligation of the inferior vena cava Contrariwise in our own limited experience with nine patients in whom ligation of the inferior vena cava was done for single or recurrent thromboembolism both the early and the late results have been completely satisfactory In three of the patients the period of follow up study is six years three months five years six months and five years seven months, respectively

GROUP IV—ACUTE THROMBOPHLEBITIS AND ACUTE FULMINATING THROMBOPHLEBITIS (PHLEGMASIA CERULEA DOLENS)

Type I—Acute Thrombophlebitis The treatment of patients with this type of deep venous thrombosis is conservative. This consists of (1) sedation (2) bed rest with elevation of the affected extremity· (3) continuous warm moist saline compresses to the whole of the extremity (4) anticoagulant and anti-

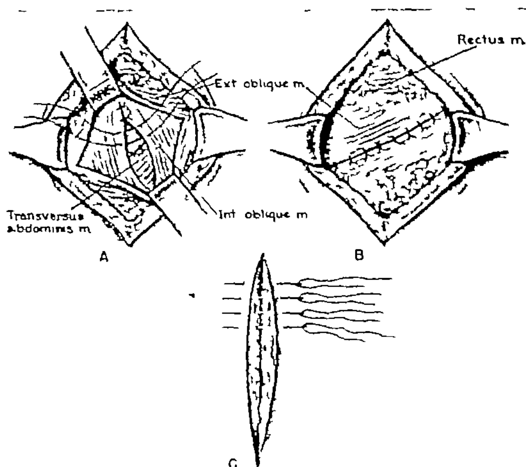


FIG. 6 A, B and C Demonstrates the layer closure of the wound, using interrupted sutures of fine silk (No 000)

Pseudoembolic Thrombophlebitis). This is caused by an extensive and rapidly propagating type of venous thrombosis Characteristically the patients are acutely and gravely ill Death within thirty-six to forty-eight hours may occur Accordingly treatment, of necessity must be early and adequate if uniformly successful results are to be obtained Despite the severe and intensive inflammatory reaction associated with this type of venous thrombosis thromboembolism frequently fatal, is not uncommon

The use of conservative measures as previously described in the treatment of acute fulminating thrombophlebitis has proved unsatisfactory Once the diagnosis is established the best method of treatment is immediate operative intervention The operative approach is dependent upon the clinical findings If the thrombus has extended into the pelvis with an associated edema of the sacral area the lower portion of the abdomen and/or beginning swelling of the opposite extremity the inferior vena cava is exposed through an anterolateral extraperitoneal approach (Fig 1) Characteristically thrombotic occlusion of the lumen of the inferior vena cava, in association with a periphlebitic inflammatory edema is present. The inferior vena cava is carefully mobilized and en

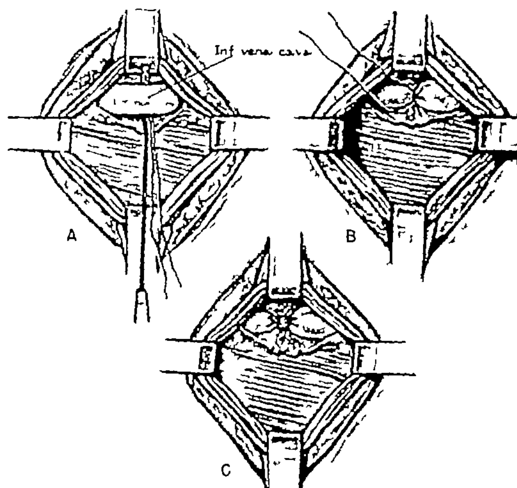


FIG 5 A. A malleable ligature carrier with a ball point protected tip is used to encircle the inferior vena cava with a ligature of silk (No. 2) B The lumen of the inferior vena cava is occluded with one silk ligature and a second is ready to be tied. C. The inferior vena cava is occluded with two silk ligatures (No. 2) The distention of the vessel distal to the ligatures is depicted.

equally satisfactory results have been obtained by the paravertebral injection of 15 or 20 cc. of the procaine solution at the level of the spinous process of the first lumbar vertebra

Although thromboembolism is not a common complication in patients in this group if it should occur ligation of the inferior vena cava is the preferred treatment. An important feature of the after care of patients in this group, whether or not operation has been performed, is the continued use of an elastic bandage support. This bandage extends from the base of the toes to the tibial tubercle It is applied to the affected extremity in the morning before arising and removed in the evening after retiring The bandage is worn daily for varying periods of six to eighteen months depending upon the individual response of the patient. When the patient is able to walk without the elastic support for ten to twelve hours and has minimal or absent subjective and objective complaints, its use may be discontinued.

Type II—Acute Fulminating Thrombophlebitis (Phlegmasia Cerulea Dolens

the large and small toes of the left foot and all the toes and part of the dorsum of the right foot. In 1951 Miles[7] in a review of the literature, added one case to the fifty-nine previously reported and described the effect of ligation of the inferior vena cava. Subsequent to this Grant and Deddish[8] reported one case and the author is herein including two cases that have not been reported previously This makes a total of sixty-three cases of phlegmasia cerulea dolens reported to date

In a review of the protocols of many of the reported cases one is impressed by the inefficiency of all phases of conservative management. In 1948 Oaks and Hawthorne[5] were the first to report and to treat this condition by ligation and division of the inferior vena cava The operation was done on July 16 1946 and a complete recovery ensued. In 1950 Young and Derbyshire[16] reported a complete success after a double ligation in continuity of the inferior vena cava The operation was performed on May 1 1947 The preoperative diagnosis was an embolic occlusion of the left common iliac artery However at operation the true origin of the symptoms i.e. phlegmasia cerulea dolens, was recognized and the inferior vena cava was occluded by ligature The recovery was complete In 1951 Miles[7] reported a completely successful result following the ligation of the inferior vena cava. The operation was done on October 17 1949 The vena cava was doubly ligated with silk (No 4) and divided To these three are added the two cases herein reported. The first was operated upon on December 22 1946 and the second on November 22, 1949 In both, recovery was complete This makes a total of five cases of phlegmasia cerulea dolens treated by ligation of the inferior vena cava and in all a completely successful result was obtained.

The one common finding in all the patients who were treated by operation was the thrombotic occlusion of the inferior vena cava, which occlusion most frequently extended to the entrance of the renal veins In the case reported by Grant and Deddish,[8] operation was not done A necropsy showed thrombotic occlusion of the inferior vena cava and massive pulmonary embolism Compromise in the circulation to both lower extremities was present

In 1949 De Bakey and Ochsner[*] reported, apparently for the first time, a complete success in the treatment of phlegmasia cerulea dolens following the opening of the superficial femoral vein the evacuation of the contained thrombi, and then the ligation and division of the vein.

In a review of the preceding it seems logical and justifiable to assume that the pathogenesis of phlegmasia cerulea dolens is an extensive and rapidly propagating thrombus blocking the deep veins of one or both lower extremities in association with a thrombotic occlusion of the lumen of the inferior vena cava This blockage of the deep veins, in association with the accompanying extensive and severe edema of the extremity causes a mechanical blockage to the arterial and particularly the arteriolar blood flow in the distal portion of the affected extremity When this occurs in patients in the older age groups in whom varying degrees of peripheral arterial insufficiency already exist, an ischemic gangrene of a part is a frequent occurrence. The role of secondary arterial spasm in the pathogenesis of this acute

circled by two or three ligatures of silk (No 2) which are not tied An incision is made in the inferior vena cava and the clots are evacuated These clots usually extend up to the entrance of the renal veins and for their removal "milking" in a retrograde manner is required. This is followed by an active retrograde flow of blood The clots in the distal portion of the vena cava are similarly removed by a "milking" maneuver of the fingers The inferior vena cava is then ligated in continuity or doubly clamped, divided, and ligated, using the ligatures previously inserted. In the immediate and late postoperative phase of treatment the use of the elastic bandage support, as previously mentioned is prescribed

This method has been used in the successful treatment of two patients. In the first patient, a twenty-five year old woman, phlegmasia cerulea dolens occurred as a complication of childbirth. At operation the lumen of the inferior vena cava was occluded completely with thrombi up to the level of the renal veins The thrombi were evacuated, and following the establishment of an active retrograde flow of blood, the inferior vena cava was ligated and divided. The recovery was complete.

In the second patient, a fifty-six year old man the symptoms occurred without any evident predisposing or contributory cause. An ischemic gangrene of the left foot occurred for which a midleg amputation was done Shortly thereafter fulminating symptoms occurred in the right lower extremity and ligation of the inferior vena cava was advised. At operation the vena cava was occluded with thrombi to the level of the renal veins The thrombi were removed until active retrograde bleeding was observed. Ligation in continuity of the inferior vena cava was then done using three ligatures of silk (No 2) A complementary lumbar sympathetic ganglionectomy was also performed. The improvement in the right lower extremity was immediate and pronounced. The subsequent improvement was progressive and the extremity resumed the normal in appearance. Three months postoperatively death occurred A necropsy was obtained The final diagnosis was carcinoma of the body of the pancreas The right lower extremity was normal in appearance.

In patients in whom the thrombotic process is more or less limited to the lower extremity the operative approach may be directed to the superficial femoral vein The clots are removed and the vein is doubly clamped, divided and ligated. The use of this method of treatment has not been employed by the author However a complete success with its use has been reported [3]

Phlegmasia Cerulea Dolens

There is one type of deep venous thrombosis that merits further discussion, first, because of its relative infrequency secondly because of a lack of uniformity of opinion regarding its pathogenesis and treatment, and, finally because of the high mortality associated with its presence I refer to acute fulminating thrombophlebitis or phlegmasia cerulea dolens

Phlegmasia cerulea dolens was first described in 1929 by Trémolières and Véran[18] and again in 1938 by Gregoire [4] In 1949 De Bakey and Ochsner added two cases to the three previously reported [1-14] in the American literature One, treated by operation recovered The other not operated upon also recovered, but suffered the loss of

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fulminating thrombophlebitus is believed a minor one. This belief is supported by the slight but inadequate response obtained after the use of single or multiple procaine (two per cent) "blocks" of the paravertebral sympathetic ganglia. On the contrary the concept of mechanical blockage is supported by the excellent results, both immediate and late, obtained after the surgical removal of the thrombi found occluding the inferior vena cava and the superficial femoral vein

Once the diagnosis of phlegmasia cerulea dolens is established conservative treatment in any or all forms is believed interdicted. The prescribed treatment is the extraperitoneal exposure of the inferior vena cava (Figs 1-4) the evacuation of the thrombi occluding its lumen until active retrograde bleeding occurs and then double ligation in continuity (Fig 5) or double ligation and division of the inferior vena cava

ARTERIAL EMBOLISM

Introduction An embolic occlusion of the lumen of a major artery is a genuine surgical emergency Unfortunately and all too frequently the diagnosis of an acute arterial embolic occlusion is not made promptly and the loss of a major part of a limb or even life itself may occur Contrariwise a prompt diagnosis may be made but valuable time is consumed frequently in the use of ineffectual methods of conservative treatment If uniformly successful results are to be obtained embolectomy should be done within six to eight hours after the onset of symptoms

In this presentation, the surgical management of patients in whom an arterial embolic occlusion occurs is detailed

Historical Aspects In 1895 Sabanejeff[13] was the first to do an arteriotomy for the removal of an embolus The embolus occluded the femoral artery The operation was not successful In the succeeding five years a total of eleven embolectomies were done and all were failures

In 1911 Labey[9] of France was the first to perform successfully an arterial embolectomy The embolus was removed six hours after it occluded the left femoral artery In 1913 Bauer[1] using the transperitoneal route, performed the first successful aortic embolectomy The duration of symptoms was three hours.

In a review of the literature up to 1922, Einar Key[6] of Sweden reported thirteen successful embolectomies In 1929 the same author[7] in a collective review of the literature up to and including 1927 reported eighty-six successful embolectomies in a series of 216 cases Of these 216 cases 145 were from Sweden.

In 1928 Pemberton[1*] in a review of the literature from the United States and Canada was able to collect only twenty cases in which an attempt at arterial embolectomy was made

Since 1928 and particularly since 1943 experience has accumulated rapidly until now arterial embolectomy is an operation that is performed frequently throughout the world with increasingly successful results

Etiology According to Bull[2] there are five possible sites of origin of a peripheral arterial embolus These are (1) a central spot in an artery especially the aorta (2) the left side of the heart (3) the pulmonary veins (4) the right side of the heart (5) the systemic veins The last two sites of origin presuppose the presence of a patent foramen ovale (paradoxical embolus)

The commonest mode of origin of a

peripheral arterial embolus is the detachment in whole or in part of a mural thrombus located in one of the chambers of the left side of the heart. In the study by Bull,[2] mural thrombi were present in one or more of the heart chambers in 86 6 per cent of the cases in which embolic gangrene of the extremities was present.

Predisposing factors to the formation of mural thrombi within the chambers of the heart are (1) an underlying heart disease (2) cardiac arrhythmias (3) congestive heart failure In coronary thrombosis with myocardial infarction, mural thrombi are a frequent occurrence An incidence as high as sixty seven per cent has been reported [4] In approximately ninety per cent of the cases the mural thrombi are located in the ventricles Contrariwise in about ninety per cent of the cases of rheumatic heart disease with mitral stenosis the mural thrombi are located in the auricles, particularly in the left auricle and its appendix. In fact a mural thrombus that occurs as a complication of rheumatic heart disease is the commonest mode of origin of a peripheral arterial embolus

In patients with auricular fibrillation mural thrombus is a frequent occurrence Garvin,[4] in a necropsy study of sixty patients with auricular fibrillation, noted the presence of mural thrombi in twenty six (43.3 per cent) whereas in fifty-one patients, without auricular fibrillation mural thrombi were present in only nine (eighteen per cent) Weiss and Davis[14] studied a group of twenty eight patients with auricular thrombi In twenty five the rhythm was determined prior to death. In twenty two of these (eighty-eight per cent) auricular fibrillation was present.

Congestive heart failure is another common finding in patients with mural thrombi and thromboembolization to the peripheral arteries Graef[3] and his associates noted its presence in twenty-one of twenty-four cases in which mural thrombi were found at necropsy In the remaining three patients, a history of previous attacks of congestive heart failure was obtained.

Not uncommonly the origin of an embolus may be the detachment in whole or in part of a thrombus overlying an atheromatous plaque in the wall of the aorta or a portion of the plaque itself Finally in some instances the blockage of the lumen of the artery is caused by an autochthonous thrombus * In many instances the differentiation between this type of thrombus and an embolus may not be possible even though an operation or necropsy be performed.

Symptoms and Signs The symptoms and signs relative to an arterial embolus vary according to the location of the embolus within the peripheral arterial tree In fact, the more proximal the site of the occlusion, the greater will be the associated clinical manifestations.

In contrast to the occlusion of the lumen of an artery by an autochthonous thrombus the symptoms of an embolic arterial occlusion are usually acute and pronounced One of the most characteristic symptoms is pain The pain may be severe and in some instances, particularly when the lumen of the abdominal aorta is occluded profound shock may be present. However in other instances the pain may be minimal or even absent. In association with the pain, the sudden loss of sensation and the impairment of function in the affected part are the two commonest complaints These latter symptoms may

* A thrombus formed where found.

occur in one of the lower extremities while walking and cause the patient to fall suddenly to the ground

Immediately following the arterial oc clusion, the part distal to the site of the embolus is cold the arterial pulsations are absent, and a waxy pallor is present. Within two to four hours, this pallor is usually replaced by a mottled cyanosis If the obstruction is not relieved and the compromise to the circulation is irrever sible a level of demarcation between the viable and the nonviable tissue occurs In addition, a mummification of the tissues in the more distal portions of the extremity is present.

Intermittent arterial spasm is a frequent accompaniment of an acute embolic occlusion The failure to evaluate its significance may cause a delay in the performance of an embolectomy beyond the optimum time limit of six to eight hours When arterial spasm is present the affected extremity is cold and pallid sensory and motor disturbances are observed the veins are collapsed, and the arterial pulsations are absent. *Contrariwise, when arterial spasm is absent*, the involved member is warm there are no sensory or motor disturbances the veins are distended and the arterial pulsa tions, though diminished, are palpable The arterial spasm is initiated by the ir ritant foreign body (embolus) within the lumen of the artery The cycle of intermittent arterial spasm and relaxation persists for three to four hours after the occurrence of the embolic arterial occlusion until the propagating thrombus occludes completely the lumen of the artery and the orifices of its collat eral branches. When this obtains, the cycle is broken and the findings indica tive of a severe arterial insufficiency are persistent. When the extremity is examined during the phase when arterial spasm is present, and again during the phase when it is absent, there is a tend-

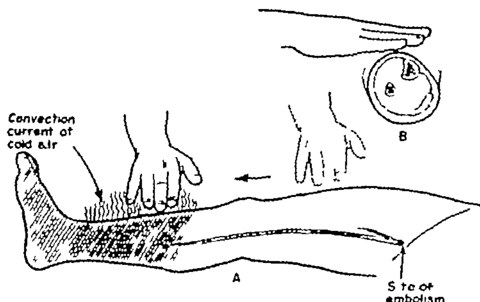


FIG. 1 Method of examination to determine the line of demarcation in the skin temperature A. The examining hand is passed from above downward in juxtaposition to but without touching the skin surface. The level of demarcation is indicated by the abrupt perception of a convection current of cool air B Cross section view to show the relation of the hand to the surface of the skin.

ency to defer operation because of the subjective and objective improvement observed However if one is cognizant of the relation between an arterial embolus and an intermittent arterial spasm, a prompt removal of the embolus will be done.

When an acute blockage of the arterial blood supply to an extremity occurs there is a sharp level of demarcation in the skin temperature which, characteristically is well below the site of blockage To determine this level



FIG. 2 Preoperative photograph of lower extremities of a patient three days after the embolic occlusion of both femoral arteries. The site of blockage bilaterally was at the entrance of the artery into Hunter's canal. In each extremity the upper line demonstrates the level of demarcation in the skin temperature the lower line, the level at which changes (irreversible) in the color of the skin were observed.



FIG. 3 Levels of demarcation in the color of the extremity after an embolic arterial occlusion. A. Popliteal artery B Femoral artery

the usual method is to palpate the skin surface, using the ulnar side of the palm or the dorsal or palmar aspects of the fingers Another method is to place the palmar aspects of the fingers within 2 cm of the surface of the skin without touching the skin (Fig 1) The hand is then passed slowly downward from the viable to the nonviable tissue area (Fig. 1) At the level of demarcation in the skin temperature, a convection current of cool air is perceived abruptly by the fingers This method of examination is believed the more sensitive of the two described and is preferred.

In addition to the abrupt decrease in the skin temperature, there is also a level of demarcation at which changes in the color of the skin occur This level is always below the one at which the changes in the skin temperature are

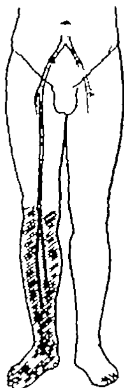


Fig 4 The level of demarcation in the color of the extremity after an embolic occlusion of the common iliac artery

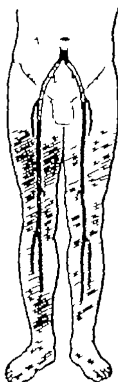


Fig. 5 Levels of demarcation in the color of the extremities after an embolic occlusion of the aorta at its bifurcation. Mottled cyanosis not infrequently ascends to the level of the umbilicus as depicted.

observed (Fig 2) In the lower extremities the levels of demarcation in the color of the skin for the different sites of embolic arterial occlusion are depicted in Figs 3 4 and 5 In the upper extremities the incidence of an irreversible compromise of the circulation after an acute arterial blockage is considerably less than in the lower extremities However an ischemic gangrene can and does occur The levels of demarcation in obstruction at the bifurcation of the brachial artery and the axillary artery are shown in Fig 6

Diagnosis: The diagnosis of an arterial embolic occlusion is not difficult if one considers the possibility of its presence and does a thorough examination of the patient. The usual precursor of a peripheral arterial embolus is a preexisting mural thrombus in one of the chambers of the heart or the wall of one of the peripheral arteries particularly the aorta. These mural thrombi are common complications of coronary thrombosis, rheumatic heart disease, and arteriosclerosis Furthermore auricular fibrillation and congestive heart failure either recent or existing are commonly associated with mural thrombosis and peripheral arterial thromboembolism

A knowledge of the location of an arterial embolus is a prerequisite for its removal Generally, an embolus lodges at the site of bifurcation of an artery In the upper extremity the obstruction commonly occurs at the bifurcation of the axillary and the brachial arteries In the lower extremity the common sites

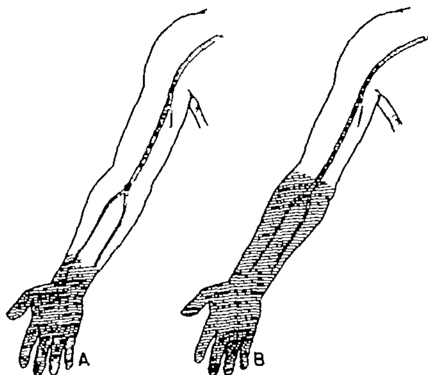


Fig 6 Levels of demarcation in the color of the upper extremity after an arterial embolic occlusion. A, Brachial artery B Axillary artery

of obstruction are the bifurcation of the abdominal aorta, the common iliac, the femoral, and the popliteal arteries

In determining the site of embolic arterial occlusion the level of demarcation in the skin temperature was at one time thought to be of diagnostic importance If this level was below the patella it was considered indicative of an embolic occlusion at the bifurcation of the popliteal artery However experience demonstrated that in an occlusion of this artery the level of demarcation in the skin temperature was not infrequently above the patella. A more accurate method is the determination of the level of demarcation in the color of the skin as previously described (Figs 3 4 5 and 6) The most accurate method is to determine the level at which an arterial pulsation is elicited However it is important for one not to confuse an arterial pulsation with the downward thrust of an embolus as described by Nordentoft.[11] If a genuine arterial pulsation is detected, one knows that the site of blockage is distal and most likely at the site of the next arterial bifurcation.

In the differential diagnosis of an acute arterial embolic occlusion one must consider always acute fulminating thrombophlebitus, frequently called pseudoembolic thrombophlebitis, or phlegmasia cerulea dolens The characteristics of this condition were previously described in detail relative to venous thrombosis Suffice it to say that pseudoembolic thrombophlebitis is associated always with an extensive edema of the affected extremity whereas in the uncomplicated acute arterial embolic occlusion edema is absent.

If one considers the preceding in as

sociation with the symptoms and signs of an acute arterial occlusion previously described, an early and correct diagnosis of an arterial embolus should not be difficult

Treatment

Prophylactic Once a peripheral arterial embolus occurs there is a high incidence of recurrence. Unfortunately the recurrent embolus frequently is fatal Since a thrombus is a precursor of every arterial embolus, the ideal prophylaxis for recurrent emboli is the removal of the thrombus together with its site of origin

Rheumatic heart disease with mitral stenosis is the commonest cause of a peripheral arterial embolus This complication reportedly has occurred in about forty five per cent of the cases [14] In this disease the origin of the embolus is most frequently a mural thrombus within the left auricle or its appendix, more frequently the latter In accordance with this anatomic peculiarity Dock[5] in 1946 suggested the resection of the left auricular appendix in patients with rheumatic mitral stenosis, auricular fibrillation and recurrent peripheral arterial emboli Within the succeeding two years two such patients were operated upon and the results were reported [9]

Since this report five patients with rheumatic heart disease and auricular fibrillation in whom there were one or more peripheral arterial embolic occlusions, were operated upon In two patients, the primary indication for the operation was the presence of recent and recurrent peripheral arterial emboli In one three clots present in the left auricular appendix were removed. In the other clots were absent In the remaining three patients, the primary indication for the operation was a progressive disability relative to mitral stenosis for which a "finger fracture" commissurotomy was done In this group peripheral arterial emboli had occurred previously at one year four years, and thirteen years respectively In the one patient who had an arterial embolus one year preceding the operation two clots were evacuated from the auricular appendix before it was resected In the other two patients, there were no clots present in the left auricular appendix. Of the total of seven patients with rheumatic mitral stenosis, auricular fibrillation and one or more recent or remote peripheral arterial emboli who were operated upon, thrombi were present in the left auricular appendix in four (57 1 per cent) Six (85 7 per cent) of the seven patients survived the operation There has been no recurrence of a peripheral arterial embolus in any of the survivors The longest follow-up is four years and six months and the shortest is four months

Mural thrombi and peripheral arterial emboli are common complications of coronary artery thrombosis. However in this type of heart disease, in contra distinction to rheumatic heart disease the mural thrombi are primarily ventricular being such in over ninety per cent of the cases

Although experience is limited, resection of the left auricular appendix is suggested as a prophylaxis for recurrent arterial emboli The one indication for the operation still remains a patient, with rheumatic mitral stenosis with or without auricular fibrillation, in whom one or more recent peripheral arterial embolic occlusions have occurred.

Definitive The basic principles that

underlie the successful surgical removal of an arterial embolus are (1) an early operation (2) an adequate surgical exposure (3) the production of a minimum of trauma particularly to the intima (4) the interruption of the circulation for a minimum period after the thrombus is removed.

The *sine qua non* of success in arterial embolectomy is early operation. This means the removal of the embolus within six to eight hours after its occurrence Frequently the diagnosis of an arterial embolus is made within the optimum time period for its removal, but unfortunately and all too often, valuable time is consumed in the prolonged use of conservative and nonoperative methods of treatment. This practice cannot be too strongly condemned. There is probably no phase of surgery where the surgical axiom "mechanical obstruction necessitates mechanical intervention" is more applicable than in arterial embolectomy

A concept accepted by many is that an embolic occlusion of the popliteal artery though an early diagnosis is made should be treated conservatively because the results obtained after embolectomy are unsatisfactory This has not been our own experience Accordingly under such circumstances, embolectomy is practiced.

Unfortunately patients may be seen eighteen to twenty four hours after the occurrence of an embolic arterial occlusion. Under such circumstances the indication for operation is dependent upon the clinical findings in the individual patient. If embolectomy is performed occasionally one may be rewarded with a completely successful and unexpected recovery In a recent experience, a patient was operated upon on the third day after the embolic blockage of both femoral arteries at the entrance into their respective Hunter's canal. The extent of the compromise in the circulation to the extremities precluded amputations at the thigh level. In an attempt to improve the circulation sufficiently to permit midthigh amputations, an arterial embolectomy and venous thrombectomy bilaterally were done. After operation the level of skin color demarcation receded to below the knee, and within the subsequent two weeks supracondylar amputations of first the right and one week later the left, lower



FIG. 7 Photographs of the surgical specimens from the patient depicted in Fig. 2. From left to right are (1) the stasis thrombi evacuated from the right femoral vein, (2) and (3) the thromboemboli removed from the right and left femoral arteries respectively



Fig 8 Photographs of the amputation stumps three weeks (left) and four weeks (right) postoperatively The first amputation (supracondylar right) was done one week after the arterial embolectomy and venous thrombectomy

extremity were performed The postoperative result is depicted in Fig 8 When an embolectomy is done late it is believed important for the development of an adequate collateral circulation to evacuate as completely as possible the stasis thrombi which occlude the lumen of the accompanying veins (Fig 7)

In the majority of surgical procedures for aortic or arterial embolectomy tape ligatures and varied mechanical devices are commonly employed to occlude the lumen of the artery both proximal and distal to the site of the embolus The use of such methods for hemostasis may cause an injury to the intima and predis-

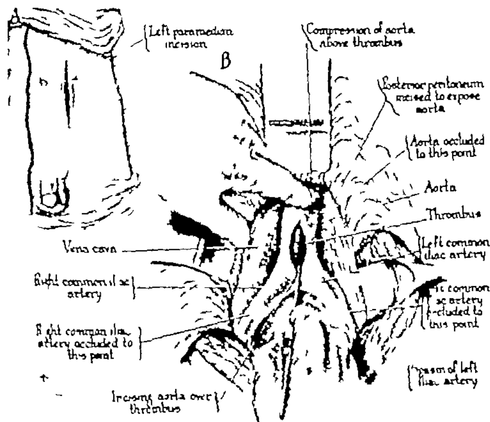


Fig 9 A. The incision employed, a left paramedian, is depicted B The lumen of the aorta is occluded by digital compression and the anterior wall of the aorta overlying the contained thrombus is incised. The thrombus which extends distally into both common iliac arteries is herniated partially through the incision. The left common iliac artery distal to the thrombus is in spasm. (By permission of "Surgery Gynecology and Obstetrics.)

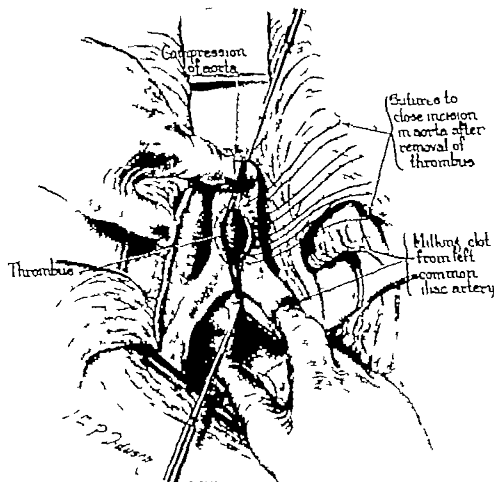


FIG. 10 Digital compression of the aorta is maintained proximal to the thrombus and the silk suture strands are retracted on nerve hooks to permit the free escape of blood clots. The thrombus, first in one then in the other common iliac artery is "milked" upward through the opening in the aorta. (By permission of "Surgery Gynecology and Obstetrics.")

pose to the formation of a local thrombus. Furthermore the mobilization of the vessels that is required enhances the danger of dislodging a portion of the thrombus and cause a secondary embolic occlusion more distally In the following description of a technic for arterial embolectomy the one used for the removal of an embolus located at the bifurcation of the aorta will be described.[10] The same technic is applicable in the removal of emboli from the more peripheral arteries.

TECHNIC FOR AORTIC EMBOLECTOMY * The surgical approach to the lower portion of the aorta and its bifurcation may be extraperitoneal, transperitoneal, or retrograde The transperitoneal approach, spinal anesthesia being used, is preferred

"A left paramedian muscle retracting (lateral) incision is employed (Fig. 9A) The incision extends approximately one third above and two-thirds below the

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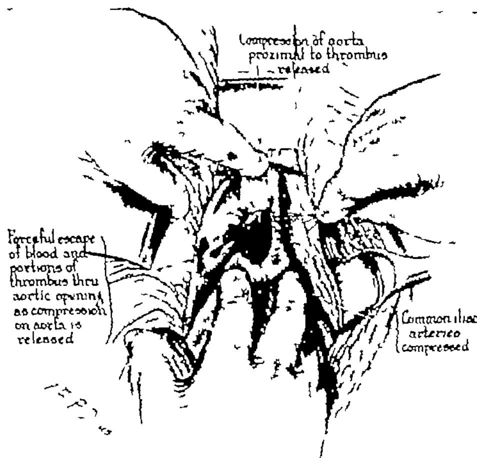


FIG. 11 To prevent the peripheral dissemination of emboli the common iliac arteries are occluded digitally and the compression of the aorta proximal to the thrombus is released. The force of the aortic pulsations ejects the clots of blood through the incision. This is followed by active pulsatile hemorrhage, the control of which is being initiated by traction on the silk suture strands. (By permission of "Surgery Gynecology and Obstetrics.")

level of the umbilicus After the peritoneal cavity is entered the patient is placed in the Trendelenburg position. The small intestines are displaced upward and are maintained in position by suitably placed moist gauze pads A linear incision is made through the posterior parietal peritoneum overlying the lower portion of the abdominal aorta and its bifurcation The surrounding fatty areolar tissue is separated by blunt dissection and the occluded segment of the aorta is exposed By digital palpation the extent of the thrombus, proximally in the aorta and distally in the iliac arteries is determined The adventitia layer is removed from the anterior surface of the distal 4 to 5 cm. of the abdominal aorta Employing the left index finger * the first assistant gently compresses the aorta immediately proximal to the thrombus (Fig 9B) A linear incision approximately 3 cm. in length is made through the anterior wall of the aorta overlying the middle portion of the contained thrombus. This per

*If for technical reasons, the use of the index finger proves unsatisfactory a 10 in. length anatomical tissue forceps may be conveniently substituted.

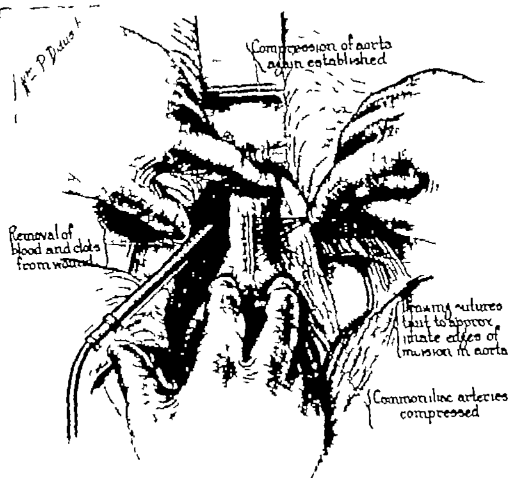


FIG. 12. After complete evacuation of the thrombus, the lumen of the aorta is momentarily occluded proximal to the incision and the suture strands of silk are drawn taut to close the opening in the aorta. The operative area is toiletted by irrigation with saline solution that is removed by suction siphonage. (By permission of "Surgery Gynecology and Obstetrics.")

mits the thrombus to extrude partially through the incision (Fig. 9B) A series of interrupted everting mattress sutures of No 00000 silk (Deknatel) swaged on a small curved needle are inserted. The silk suture strands that overlie the herniated segment of the thrombus are separated into two divisions and are retracted on nerve hooks both proximally and distally respectively (Fig. 10) By digital compression the distal portion of the thrombus, first in one and then in the other common iliac artery is milked" upward and extruded through the incision in the aorta (Fig 10) Subsequent to this maneuver and provided an early operation is performed, free retrograde bleeding usually occurs This bleeding indicates patency of the collateral vascular channels below the site of the aortic occlusion a favorable prognostic sign. Next, the common iliac arteries are occluded with digital compression immediately distal to the bifurcation of the aorta by the right hand of the assistant or the left hand of the surgeon, and the compression of the aorta proximal to the thrombus is slowly re-

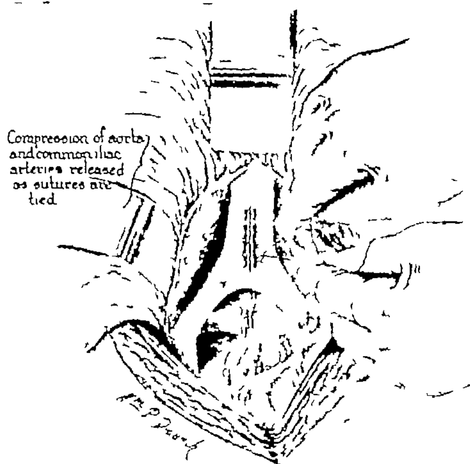


FIG. 13 The compression of the aorta and the common iliac arteries is released and the occluding traction sutures of silk are tied. (By permission of "Surgery Gynecology and Obstetrics.")

leased (Fig. 11) The arterial pressure in the aorta generally is sufficient to expel forcibly the remaining portion of the thrombus through the aortic incision If not, the thrombus may be evacuated by milking it downward by gentle digital compression. The digital occlusion of the common iliac arteries prevents the dissemination of thrombotic emboli into the peripheral arteries The discharge of the thrombus is followed by a forceful pulsatile flow of blood that is stopped by the compression of the aorta proximally by means of either the index finger (Fig. 12) or an anatomical tissue forceps The operative field is cleansed by irrigation with sterile saline solution which is removed by suction. The silk everting mattress sutures previously inserted are drawn taut, the compression of the aorta is released, and the sutures are tied (Fig. 13) If sites of bleeding should persist hemostasis is obtained either by gentle compression of the suture line for several minutes by means of a sterile gauze sponge or by the insertion of additional interrupted silk sutures, dependent upon the severity of the hemorrhage

"Five cc (50 mg) of heparin are

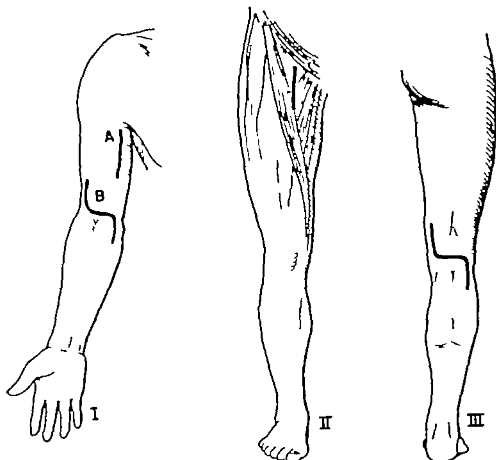


FIG. 14 Sites of incision for peripheral arterial embolectomy
I. A Axillary artery B Brachial artery
II Femoral artery
III Popliteal artery

injected into the lumen of the aorta proximal to the arteriotomy and maintained *in situ* for one minute by digital compression of the aorta both above and below the site of incision The incised portion of the posterior parietal peritoneum is not sutured. A layer closure of the wound is performed, interrupted silk sutures being used. Drainage of the wound is not employed. Because of the high incidence of complications due to hemorrhage, anticoagulant therapy postoperatively has been discontinued"

In the technic described, the left index finger or a long anatomical tissue forceps is used for hemostasis This method produces a minimum of trauma, does not require the mobilization of the aorta, and permits the immediate release or application of a compression force to the aorta a desired technical aid.

Before doing the aortotomy the lumen of the aorta is occluded proximal to the thrombus Following the aortotomy the thrombus herniates partially through the incision This herniation of the thrombus causes an eversion of the incised margins of the intima and permits the meticulous insertion of the everted mattress sutures of fine silk. After the thrombus is evacuated traction upon the

previously inserted sutures closes the incision in the aorta and controls the hemorrhage Accordingly proximal occlusion of the aortic lumen and interruption of the circulation is only momentary while the sutures are drawn taut In strumentation of the lumen of the aorta or a peripheral artery is believed too traumatic and it is judiciously avoided It is considered both unnecessary and unwarranted

Lumbar sympathetic ganglionectomy or paravertebral lumbar sympathetic ganglion "blocks" (procaine, two per cent) are not used either as a preliminary or as a complementary procedure to arterial embolectomy A supplementary lumbar sympathetic ganglionectomy may be done dependent upon the demands of the individual patient.

Anticoagulant therapy either preoperatively, or in particular postoperatively is no longer prescribed because of the serious complications due to hemorrhage that may and have occurred. In two patients postoperative hemorrhage attributable to anticoagulant therapy was the immediate cause of death. In this regard one may justifiably state that the method employed in the use of the anticoagulant was at fault and that the condemnation is unmerited. Acceptable as this objection may be, it is the expressed feeling of the author that if embolectomy is done early the use of anticoagulants is unnecessary If the operation is performed late the anticoagulants are of little or no value and finally if the time factor is borderline the disadvantages in their use are believed to exceed the many proclaimed advantages. The experiences to date have served more to strengthen than to weaken one s opinion in this regard.

If uniformly successful results are to be obtained in arterial embolectomy it is believed essential that the four basic principles previously described be closely adhered to To repeat these are (1) an early operation preferably within the first six to eight hours (2) an adequate surgical exposure (3) the production of a minimum of trauma, particularly to the intima (4) the interruption of the circulation for a minimum period after the thrombus is removed

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Cardiac Arrest During Anesthesia and Surgery

THE sudden unexpected cessation of effective cardiac activity during an operative procedure is a catastrophe to the surgeon and the patient's family alike In the past the surgeon told the family that the patient "took the anesthesia poorly" In recent years it has often been possible to recover from this catastrophe by promptly instituting a preconceived program of therapy There is ample evidence that the brain will seldom recover after more than about four minutes of a complete absence of blood flow It is obvious therefore that very little time can be lost in making the diagnosis and instituting treatment. The implications of this emergency are so staggering, especially when it occurs in a healthy individual and the treatment required is so "heroic," that few surgeons or anesthetists are prepared for successful management unless the plan of attack has been thought through beforehand It is obviously important therefore for every surgeon and anesthetist to become familiar with all aspects of this problem

Types of Circulatory Arrest The sudden cessation of effective circulation is usually due to one of two causes The first is *cardiac asystole* in which all cardiac activity has ceased. The second is *ventricular fibrillation* in which ventricular fibers continue to contract, but asynchronously without propelling blood A third possibility is that the heart is beating so feebly that signs of effective circulation are not detectable

Incidence: Fortunately cardiac arrest and ventricular fibrillation are not common The exact incidence cannot be stated with certainty Our own experience and reports from other similar surgical services indicate that sudden circulatory arrest may be expected to occur perhaps once a year in most hospitals in which much major surgery is done The relative infrequency of this emergency should not be regarded as a basis for ignoring it because experience has shown that a high percentage of the patients can be saved if treatment is instituted promptly and skillfully carried out. The incidence of ventricular fibrillation is undoubtedly higher in institutions which sponsor an active program of cardiac surgery

Etiology—Its Relation to Prognosis. The cause of cardiac arrest has a great deal to do with the prognosis There is little point for example in attempting cardiac resuscitation when

death has been anticipated as the result of any of the usual medical or surgical causes. When the heart stops suddenly and unexpectedly due to a transient condition, the heart tends to start beating again if it is oxygenated adequately until the unfavorable condition can be removed

One or more of a number of factors may contribute to the production of cardiac arrest. An overdose of an anesthetic agent or an idiosyncrasy to a normal dose of an anesthetic agent is a common cause of cardiac arrest. In this situation the problem is merely that of maintaining an artifical circulation and respiration until the anesthetic agent is washed out or destroyed

The cause of asystole in some instances appears to be a harmful circulatory reflex initiated by such maneuvers as the insertion of an endotracheal tube dissection of the posterior aspect of the pulmonary hilum, or traction on one of the great vessels. These reflexes are thought to be mediated through the vagus nerve and are called vago-vagal reflexes Under these circumstances if cardiac massage is instituted quickly the heart is apt to recover a normal rhythm in a very short period of time

A frequent and very serious cause of cardiac arrest is anoxia. This may be due to a low oxygen content of the arterial blood or to a decrease in the coronary blood flow due to hypotension and blood loss In such a situation there may have been considerable myocardial damage before cardiac arrest actually occurred It is doubly important therefore to institute resuscitation therapy quickly The restoration of a normal rhythm will occur in a previously normal heart if the period and intensity of anoxia has not been too great. A primarily diseased heart is not so apt to recover

In the presence of anoxia the heart is much more susceptible to the noxious effects of an anesthetic agent or vagal stimuli.

Ventricular fibrillation may occur under the same circumstances as asystole It is more likely to occur under circumstances which increase the myocardial irritability Cyclopropane is thought to be a common agent in increasing myocardial irritability This effect appears to be enhanced by a high concentration of epinephrine which may be present as the result of excitement, anoxia, or therapeutic administration Direct manipulation of the heart is a potent cause of ventricular fibrillation even when the heart is normal The danger is increased by heart disease anoxia, or irritability of the myocardium due to any cause Ventricular fibrillation often occurs during cardiac massage for cardiac arrest.

Diagnosis. A delay in diagnosis is the greatest cause for failure in cardiac resuscitation The anesthetist must maintain constant observation of the patient if he is to notice asystole the moment it occurs

If one happens to have an electrocardiogram attached to the patient at the time, ventricular fibrillation may be picked up immediately and if cardiac arrest is present a profound change occurs even though not a complete cessation of electrical impulses

When the anesthetist notices the absence of a pulse or blood pressure the question always arises as to whether the heart is beating so feebly as to be undetectable or whether it is in stand-still or ventricular fibrillation If the surgeon is operating in the chest, he can see or feel the heart If he is operating in the abdomen, he should immediately feel the heart through the diaphragm.

If he is operating in the neck or an extremity one of the large arteries may be palpated.

If the heart or a large artery cannot be immediately palpated, time should not be wasted upon other diagnostic methods This is no time for consultation or speculation. The quickest and most reliable way to ascertain whether the heart has stopped is to open the chest and see or feel it We therefore have taken the point of view that the surgeon should consider opening the chest as a diagnostic procedure If the anesthetist cannot obtain a pulse or blood pressure, the surgeon must accept his observation and open the chest without losing valuable time in attempting to confirm these observations or in trying to make a diagnosis of cardiac arrest by time-consuming and unreliable diagnostic methods

Once the decision has been made to open the chest, the surgeon should be prepared to do so with the greatest dispatch. Every surgeon should be prepared to meet this emergency The surgeon needs only a pair of gloves and a scalpel Even the gloves should be dispensed with if they are not immediately available Once the scalpel is at hand, the surgeon should have his hand on the heart within fifteen seconds Skin antiseptics and sterile drapes are refinements which can be added when available, but their absence should not cost the patient his life

The incision should be made in the left 4th interspace from about the edge of the sternum to the midaxillary line Since there is no bleeding, the incision can be carried quickly through the chest wall This should not be done with one stroke of the knife for fear of cutting into the lung or heart The surgeon can put one hand between the 4th and 5th ribs to feel the heart Whether or not the heart is beating effectively will be immediately apparent Whether the heart is in stand-still or in ventricular fibrillation is not important at this point in the procedure

Treatment The immediate problem is one of producing adequate blood flow by intermittent cardiac compression and adequate oxygenation of the blood by artificial ventilation of the lungs. This must be done within three to four minutes after the cessation of blood flow if success is to be attained If the heart is in asystole it will usually start beating spontaneously following such therapy If ventricular fibrillation is present or should develop further treatment is almost always necessary

Artifical Respiration Adequate respiration can be maintained with an anesthesia machine by manual compression of the breathing bag A tight fitting face mask is satisfactory It is not wise to take time to insert an endotracheal tube until the patient is again well oxygenated One hundred per cent oxygen should be used.

If the emergency should arise outside of the operating room the patient's lungs should be ventilated by the mouth-to-mouth technic, until other equipment becomes available The Kreiselman bellows is convenient for emergency use An endotracheal tube oxygen and a breathing bag should be obtained as soon as possible however

Artifical Circulation As soon as the surgeon puts his hand on the heart and finds that it is not beating, he should start compressing it rhythmically If a rib spreader is not immediately available he should divide the fourth and fifth cartilages *with a knife or scissors in his left hand as he compresses the* heart with the right hand in order to

gain better exposure and prevent the ribs from pressing against his hands Even after dividing these cartilages the rib spreader is of great help Following successful cardiac resuscitation, a few open vessels will begin to bleed and must be caught as soon as hemostats are available.

There are a number of factors which greatly influence the effectiveness of the blood flow produced by cardiac massage

(1) *Rate of Cardiac Massage* A review of the literature reveals a difference of opinion as to the rate at which the heart should be compressed. Most writers recommend twenty to forty times a minute, in order to allow the ventricles to fill adequately while a few have suggested a normal rate Because of this difference of opinion we studied this problem in dogs By measuring blood flow with the bubble meter of Dumke and Schmidt inserted in the thoracic aorta, it was found that a greater blood flow was produced when the heart was compressed at a rapid rate Rates of 30 60 and 120 compressions per minute were compared. In all instances the blood flow increased as the rate of compression was increased, regardless of whether the heart felt full or empty

As the result of these experiments we became convinced that, in patients, one should compress the heart as rapidly as feasible, *i.e* from 80 to 100 times per minute The fatigue of the operator makes a rate of 120 times per minute impossible for more than a few minutes, whereas he can continue for a much longer time at sixty to eighty times per minute If there are two or more operators who can take turns, a faster rate may be constantly maintained.

(2) *Technic of Cardiac Massage* In the laboratory it was found that some practice was required to produce an effective blood flow by cardiac massage The dog s heart can be compressed most effectively by placing the thumb in front and the fingers behind. It was found that the blood flow produced by compressing the heart against the anterior chest wall was only about one-half as great as by the above method. Only one-fifth as much blood flow could be produced by compressing the heart through the diaphragm.

The amount of blood flow produced by artificial respiration alone was too small to be measurable by this technic. Any hope that artificial respiration is an effective method of producing blood flow should be abandoned.

A small human heart may be compressed with one hand, as in the dog. The usual adult heart can be more effectively compressed, with less effort, by placing one hand in front and the other behind the heart.

Some workers feel that the heart can be compressed more satisfactorily if the pericardial sac is opened. We do not believe that this is necessary A serious objection to opening the pericardial sac is that there is an increased risk of pushing a finger through the auricular wall or even the wall of the right ventricle

(3) *Blood Volume* It was found in the laboratory that the venous return to the heart is very important in producing maximal rates of blood flow even though it was not profitable to wait for the heart to fill between cardiac compressions. The cardiac output varied directly with the rate of cardiac compression as mentioned above. Nevertheless the cardiac output could be still further increased by rapid transfusion of blood, plasma, or plasma substitutes When intravenous fluids were given rapidly the heart could be felt to fill more

completely and the cardiac output was found to be increased even though the compression rate remained the same Some care is necessary to prevent over transfusion since there is little blood loss

(4) *Diversion of Blood Flow* In most instances the heart will resume beating fairly soon if it is going to do so Occasionally it may start up after a prolonged period of artificial respiration and circulation In such instances it may be well to divert a good part of the blood flow to the brain, since brain tissue is most quickly affected by anoxia, whereas in normal adults the descending thoracic aorta can be clamped for thirty minutes with no ill effects We were able to show that the carotid blood flow was greatly increased by occluding the descending thoracic aorta

DRUGS It is probable that no drugs are helpful in getting the heart to start beating again Once the heart has started epinephrine may be helpful in increasing the tone of the cardiac muscle and the effectiveness of its contraction. This drug probably does increase the risk of ventricular fibrillation, as has been stressed by some workers Calcium chloride (ten per cent) injected into the cardiac cavity has increased the effectiveness of the cardiac contraction in some instances when epinephrine failed Intravenous or intracardiac procaine or pronestyl may be useful in decreasing the likelihood of the heart going from stand-still to ventricular fibrillation or if ventricular fibrillation is present may help in restoring a normal rhythm Opinion is divided as to whether it should be used since it may decrease the effectiveness of the heart beat once it is restored

VENTRICULAR FIBRILLATION If when the thorax is opened the heart is found to be in ventricular fibrillation, or if fibrillation should develop during the cardiac massage the problem takes on another aspect. Usually the diagnosis can be made by palpation, since the irregular muscular twitchings characteristically feel like "a bag of wiggling worms" Sometimes however the fibrillary twitchings occur in such fine components that they may not be readily palpable Inspection of the myocardium by opening the pericardium may reveal the diagnosis

The usual causes of ventricular fibrillation are anoxia, mechanical trauma electric shock, and drugs which increase the irritability of the heart Clinically anoxia results commonly from coronary occlusion or respiratory obstruction during anesthesia. The heart may be stimulated by manipulation during many intrathoracic operations but ventricular fibrillation has occurred most commonly during operations upon the heart and pericardium Local and intravenous procaine have been shown both experimentally and clinically to protect the heart against irregularities resulting from mechanical stimulation Its use is limited by the fear of decreasing the effectiveness of the heart-beat

In rare instances ventricular fibrillation has reverted to normal rhythm spontaneously In some the use of procaine has apparently caused reversion to normal rhythm but electric shock therapy developed by Wiggers and by Beck and Mautz, must usually be employed This method of treatment is based on the observation that passage of a strong current through the heart will cause a simultaneous contraction of all the incoordinated fibrillating fibers and relaxation follows The heart is then in stand-still In animals the spontaneous heart beat resumes after a short period

of cardiac massage. In most of the patients hearts defibrillated by us, the spontaneous heart beat has begun after a short interval of stand-still.

Before defibrillation is attempted, anoxia must be overcome by cardiac massage and artificial ventilation of the lungs with oxygen. It is useless to attempt to defibrillate an anoxic heart.

The Defibrillator The purpose of the defibrillator is to stop the heart by electric shock. This can undoubtedly be done in most instances by using the regular house current (110 volts 60 cycle AC) This current is stronger than that usually required especially for small hearts. The main purposes of the defibrillator are to reduce this current to a safer strength and to isolate the current passing through the electrodes from the ground, thereby protecting the surgeon and the anesthetist. A circuit diagram of an easily constructed defibrillator which we have found to be satisfactory is shown in Fig. I It consists of an isolating transformer which may also step up the current to 130 volts, if desired, a variable resistance coil, an ammeter and two electrodes with insulated handles for application to the heart.

It is our practice first to set the resistance so that 1.5 amperes are delivered by a short-circuit test of the electrodes *i.e* with the electrodes in contact with each other Such a current should be adequate for a small heart. If defibrillation does not occur the resistance may be decreased or entirely removed for large hearts Unless the patient's whole body is thrown into a

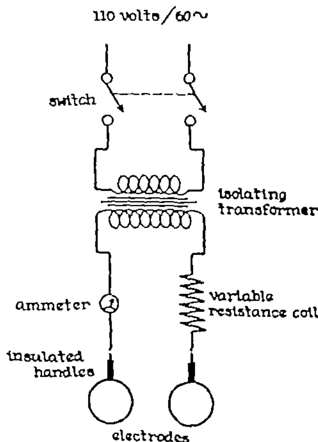


FIG. 1 Defibrillator

violent contraction, the current is probably not strong enough In an occasional very large heart, repeated shocks with no resistance may be successful when the first series was not

Currents of 220 volts have defibrillated very large hearts when lesser currents were not successful. In all instances with which we are familiar however the patient subsequently died It may be that such currents burn the heart irreparably Certainly currents of more than 130 volts should be used only as a last resort

In using the defibrillator it should be remembered that the purpose of the current is to put the patient's heart in standstill but not the heart of the surgeon or anesthetist. There is no great hurry to use the defibrillator Since the patient's tissues are being oxygenated by an artificial circulation and respiration time can be taken to use the defibrillator cautiously The electrodes to be applied to the heart should have nonconducting handles The surgeon should wear two pairs of gloves to decrease the likelihood of exposure through a glove hole. The surgeon should stand on a wooden stool and avoid touching the steel operating table when the shock is applied. The anesthetists should remove his hands from the patient and from the table when the shock is applied. If this is impossible, he should wear two pairs of gloves

With the electrodes in place the current is applied in a series of three short exposures of less than a second each Longer applications of the current are apt to burn the heart If the heart is so large that a current of 1.5 amperes (by the short-circuit test) does not suffice the current should be increased by reducing the resistance in the circuit.

Clinical Experience During the five year period before 1951 there were about 60 000 operations done at the Hospital of the University of Pennsylvania. In this group cardiac resuscitation was attempted eleven times, with eight complete recoveries. Four of these required defibrillation by electric shock. This experience and the records of many others attests to the fact that lives can be saved if anesthetists and surgeons are conditioned to this problem

As the experience in this hospital has grown the concept of opening the thorax quickly in cases of suspected cardiac arrest has been repeatedly stressed to the personnel of the departments of Surgery and Anesthesiology As a result, three of the eight patients who survived owe their lives to members of the resident staff who upon the advice of the anesthetist that signs of effective circulation had ceased acted quickly without the delay of consultation

In taking the point of view that opening the thorax is a diagnostic procedure when the anesthetist cannot obtain the pulse or blood pressure, it is inevitable that the chest will occasionally be opened when the heart is beating feebly This occurred once in this series and fortunately this was in a thoracic patient, whose operation was then performed through the same incision There is little doubt that more lives will be lost by delay in thoracotomy when cardiac arrest is present than by proceeding with thoracotomy when the heart is beating feebly

Prophylaxis Reference to the section on Etiology brings out the fact that much of the responsibility for prophylaxis falls on the anesthetist There is evidence that preanesthetic medication is important, particularly the administration of an adequate dose of atropine

Anesthetic agents must be cautiously chosen and administered, and anoxia must be avoided Maintenance of a normal arterial oxygen saturation is particularly important in patients with heart disease. The surgeon should avoid harmful maneuvers such as strong traction on the pulmonary hilum In operations on the heart, the use of procaine or pronestyl intravenously and procaine locally before the heart is manipulated probably reduces the likelihood of ventricular fibrillation. When given intravenously however it probably reduces the effectiveness of the heart-beat.

Summary: The methods which have proved successful in resuscitating patients with cardiac arrest and ventricular fibrillation have been discussed. The prime requisite for success is that the flow of oxygenated blood to the brain, produced by artificial circulation and ventilation must be restored within three to four minutes after the cessation of effective spontaneous cardiac activity It has been stressed that delay in diagnosis is the usual cause of failure and that a definite diagnosis can be made only by palpation of the heart or a large artery Since the time factor is so important to success, all surgeons and anesthetists should become sufficiently familiar with the technic of cardiac resuscitation to be ready to act on a moment's notice

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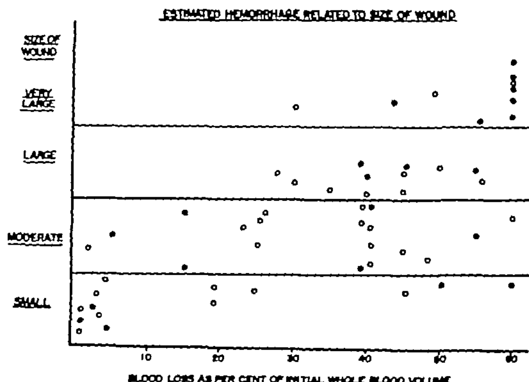
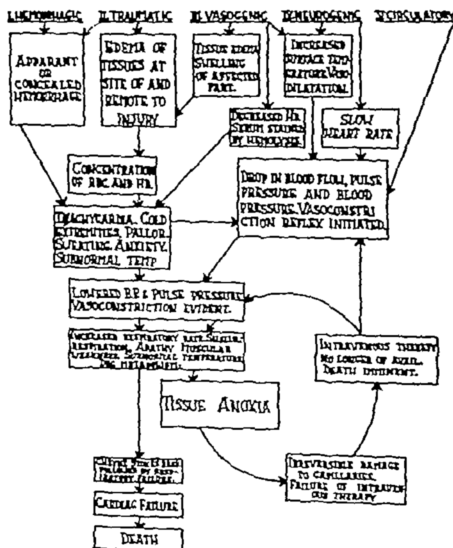


FIG. 1 (Reeve E. B. Ann. N Y Acad. Sc. 55 359 1952.)

The appreciation in reduction of blood volume has led to earlier blood replacement and reduction in mortality

Seeley has summed up in Chart 2 the various signs and symptoms which occur at various intervals in the development and establishment of shock Experience has shown that the concealed hemorrhage may be not only in a body cavity but also around the site of fracture and injury The edema of tissues at the site of injury was measured quantitatively by Blalock [8] Fox[9] working with mice using Rosenthal's[10] technic of producing tourniquet shock has added to this knowledge He analyzed the tissues for water content, sodium and potassium as well as measuring the distribution of radioactive potassium He reported these changes in concentration in terms of total tissue water His findings support the former ones of Osterhout[11] who analyzing the sap of Valonia cells proved that as a result of injury these cells lost potassium took up sodium and became swollen In the traumatized tissue as measured by Fox, there is a considerable gain in water with a loss of two-thirds of potassium and a two-fold increase in sodium In the opposite uninjured leg there is no loss of water but an increase in potassium with a corresponding decrease in sodium Fox continues this "removal of sodium without water from extracellular fluid reduces its sodium concentration (and total cation) and hence lowers its osmotic pressure Uninjured cells imbibe water from this hypotonic fluid " "This swelling of cells of uninjured tissue combined with the decreased sodium content and hence reduced volume of extracellular fluid in such regions accounts for the apparent contradiction that the water content of



(Seeley S. F Bull. U S Med. Dept. 9 300 [Jan.] 1949)

uninjured tissues is not significantly reduced despite the large amount of fluid gained by the injured region."

Chart 2 illustrates that with the drop in flood flow pulse pressure, and flood pressure vasoconstriction is initiated due to various reflexes A vicious cycle of decreased cardiac return, decreased cardiac output, and tissue anoxia takes place.

Engel in discussing the metabolic changes in shock states "If it be conceded that the various metabolic aberrations which have been catalogued above are to be considered as consequences of the anoxia attendant on the circulatory failure of shock, and that their persistence must, of necessity lead to cellular and enzymatic disorganization and death, then it is apparent that the

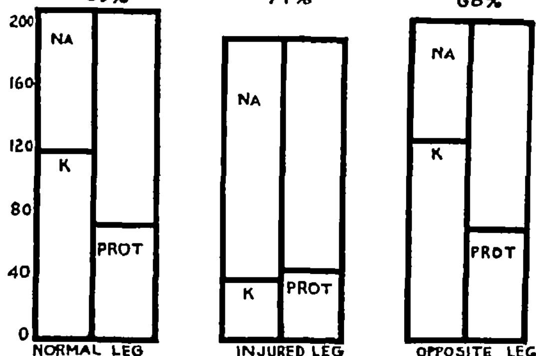


FIG. — Water sodium, potassium, and protein of normal, injured and opposite leg (Fox, C L., and Baer H Amer J Physiol 151 1 1947)

first approach to the problem of the successful therapy of shock still lies in the continued improvement of methods for sustaining the circulation"

He sums up "the management of clinical shock is going to be in terms of restoration of blood and extracellular fluid volume and the control of bacterial invasion"

Eder[1] treated the effect of shock on the kidney at the Shock Syndrome in the Annals of the New York Academy of Sciences He pointed out that this syndrome was known by a variety of names, including "lower nephron nephrosis, acute tubular necrosis and necrotizing nephrosis" He presented evidence that in the presence of reduced blood pressure there was reduction in renal blood flow and that this renal blood flow was reduced more than the cardiac output When the renal ischemia is of short duration there is no permanent injury to the kidney He concluded his paper "Acute renal failure occurring after shock is due to the period of acute renal ischemia present during shock When the shock is of short duration damage to the kidney is slight When shock is prolonged, severe damage to the kidney may result, so that the patient may recover from shock only to die of uremia While the treatment of acute renal failure has steadily improved with better understanding of the physiological disturbance the treatment of choice is the prevention and early and adequate treatment of shock"

At the Army symposium on shock, Moore[11] pointed out "After single mas-

INTERMEDIARY METABOLISM DURING SHOCK

MUSCLE
BLOOD
LIVER
BLOOD
MUSCLE

GLYCOGEN
INORGANIC PHOSPHATE
GLYCOGEN
PROTEIN
PROTEIN
ATP - ADP
CREATINE PO_4
PEPTI DASES
PEPTIDASES
PEPTIDASE ACTIVITY
GLUCOSE 6 PO_4
GLUCOSE
GLUCOSE 6 PO_4
AMINO ACIDS
AMINO ACIDS
AMINO ACIDS
PYRUVATE-PO_4
PYRUVATE
PYRUVATE PO_4
KREBS CYCLE
NH_3
NH_3
CO_2
LACTATE
LACTATE
LACTATE
UREA*
UREA
ATP ADP
CREATINE PO_4
LACTATE / PYRUVATE
KREBS CYCLE
ACETATE
KETONES
KETONES
KETONES
FAT

KEY — NORMAL
EARLY SHOCK
LATE SHOCK
LEVELS
RATES
*TOTAL UREA PRODUCTION
F.L. ENGEL
DUKE UNIVERSITY

(Engel, F L. Ann. N Y Acad Sc. 55 388 1952.)

sive trauma and hemorrhage, three categories of biological response are set in motion The first is adrenal medullary discharge with autonomic overactivity the phenomenon which we all associate with the name of Walter Cannon, and which manifests itself first by tachycardia and a narrow pulse pressure The secretion of the adrenal medulla epinephrine and its close relatives also stimulates the second set of responses, that of the adrenal cortex This results in an increased supply of steroids to the periphery And, thirdly there occurs a redistribution of body water in part determined by these endocrine factors, and in part by physical and chemical forces acting across the capillary and cell membranes "

According to Selye [17] stress stimulates the anterior pituitary and adrenal mechanism. There is no increased activity of secretions of the adrenal without prior activation of the anterior pituitary The fall in circulating eosinophils the decrease in adrenal cholesterol content and the fall in the adrenal ascorbic acid according to Long[10] "may be used as an indirect method for determining that a given set of circumstances has actually produced an activation of the anterior pituitary adrenal cortical system " "It is known " continues Long "that exposure to cold anoxic anoxia, operative procedures as well as unilateral adrenalectomy hemorrhage, bacterial toxins or burns or scalds are followed by falls in the adrenal cholesterol which in their degree and time relationships are quite comparable to those that are produced by the injection of ACTH " Long also calls attention to the decrease in the adrenal cholesterol after periods of shock and burns

In conclusion Long states, "I am very much of the opinion that the administration of adrenal cortical steroids for the treatment of shock at the best could only be a secondary measure."

As has been previously stated as a result of injury the cells lose potassium and take up sodium and water In the uninjured tissue there is hidden loss of water brought about by swelling of all the uninjured cells The distribution of water in man is as follows Total water sixty-one per cent of body weight, intracellular water forty-one per cent, extracellular water twenty per cent.

According to Randall s measurements and others, in mild shock there is a fifteen to twenty per cent blood volume loss or 750 to 1100 cc in a 70 kg (154 pound) man. In moderate shock there is from twenty to thirty per cent loss representing a decrease of 1100 to 1700 cc and in severe shock with blood losses from thirty to fifty per cent or more 2000 to 3000 cc need to be replaced Randall[13] concludes "It seems likely that, from the clinical standpoint, there is reason for the use of oral and parenteral fluids in addition to blood or blood substitutes, in the treatment of hemorrhagic and traumatic shock The extracellular fluid is effectively depleted either through localization in a third space area of trauma or by external loss, and restoration to maintain normal volume is logical. In addition patients surviving shock have definite baseline requirements of water which must be met. In dogs at least, and probably in man the administration of fluid and electrolytes of the extracellular fluid type may accelerate compensation of the circulating volume The use of oral hypotonic saline bicarbonate mixtures may form an essential part of the treatment of mass casualties in the event of a major disaster "

According to Fine [8] "Intravenous saline is better than nothing at all, but

not much better except when there is an existing need for the correction of an extravascular deficit arising from dehydration." This is in variance with the recommendation of Fox[4] who from his animal experiments advocates large amounts, even up to ten per cent of body weight, with balanced salt solutions. Fine[4a] further recommends "Oral saline is satisfactory for salt and water deficit due to burns when there is no shock or when there is only mild shock. When shock is overt, intestinal absorption is deficient, and the fluid may remain in the gut or be vomited and aspirated. It may therefore, be harmful even dangerous, rather than helpful."

It has been known that infection may lead to profound shock. The following factors may be concerned as summed up by Altemeier.[1]

"1 Loss of fluid from the circulation with diminished blood volume and hemoconcentration.

"2 A disparity between the circulatory blood volume and the size of the vascular bed may also be caused by an uncompensated increase in the size of the vascular bed

"3 Circulatory failure due to a profound toxemia and direct action upon the heart.

"4 Toxic effect of the infection on the adrenal glands.

"The acute infection which may produce this syndrome include those produced by Cl. *welchii*, hemolytic streptococci, hemolytic staphylococci, pneumobacilli, meningococci, gram negative bacilli and a mixed bacterial flora."

In the preantibiotic era overwhelming sepsis was a familiar form of irreversible shock. Fine points out that the occasional patient in protracted hemorrhagic shock will die in spite of adequate blood volume replacement.

In the laboratory Fine was able to show that dogs who had been subjected to standard experimental hemorrhage and retransfusion showed only a fourteen per cent survival whereas those animals who were given aureomycin or neomycin orally for a number of days in their food and a large dose just before the experiment, had an eighty-eight per cent survival. Fine states "It seems necessary to have an effective intraintestinal antibiotic operating from the beginning of the shock experiment in order to prevent this development of irreversibility."

He continues "An effective antibiotic corrects peripheral vascular collapse in septic shock without transfusion, and prevents hemorrhagic shock from becoming refractory to transfusion." He recommends "All patients in shock which does not respond to transfusion, should receive antibiotic therapy whether or not a pathogenic bacterial invader appears to be present, for the time required to find and identify an infecting agent should not be allowed." He also recommends "Prompt excision of a traumatic site if compatible with survival."

This chart puts graphically the various time honored and proved practices in the treatment of shock caused by various etiological agents. In the replacement of blood volume blood transfusions with properly cross-matched blood stands first. Second choice has been the use of low-titer Group O blood as so well demonstrated in World War II. Not only is blood the ideal fluid but as Moore[11] has pointed out the red cell on account of its space-occupying property is not lost through the capillaries. With transfusions there is a certain minimum of danger. In lieu of blood or until it can be obtained, blood substitutes or plasma volume expanders

sive trauma and hemorrhage, three cate gories of biological response are set in motion The first is adrenal medullary discharge with autonomic overactivity the phenomenon which we all associate with the name of Walter Cannon, and which manifests itself first by tachy cardia and a narrow pulse pressure The secretion of the adrenal medulla epinephrine and its close relatives also stimulates the second set of responses, that of the adrenal cortex. This results in an increased supply of steroids to the periphery And, thirdly there occurs a redistribution of body water in part de termined by these endocrine factors, and in part by physical and chemical forces acting across the capillary and cell membranes"

According to Selye [17] stress stimulates the anterior pituitary and adrenal mechanism There is no increased activity of secretions of the adrenal without prior activation of the anterior pituitary The fall in circulating eosinophils the decrease in adrenal cholesterol content and the fall in the adrenal ascorbic acid ac cording to Long[10] "may be used as an indirect method for determining that a given set of circumstances has actually produced an activation of the anterior pituitary adrenal cortical system" "It is known" continues Long "that exposure to cold anoxic anoxia, operative procedures as well as unilateral adrenalectomy hemorrhage, bacterial toxins or burns or scalds are followed by falls in the adrenal cholesterol, which in their degree and time relationships are quite comparable to those that are produced by the injection of ACTH" Long also calls attention to the decrease in the adrenal cholesterol after periods of shock and burns

In conclusion Long states "I am very much of the opinion that the administration of adrenal cortical steroids for the treatment of shock at the best could only be a secondary measure."

As has been previously stated as a result of injury the cells lose potassium and take up sodium and water In the uninjured tissue there is hidden loss of water brought about by swelling of all the uninjured cells The distribution of water in man is as follows Total water sixty-one per cent of body weight, intracellular water forty-one per cent, extracellular water twenty per cent.

According to Randall's measurements and others in mild shock there is a fifteen to twenty per cent blood volume loss or 750 to 1100 cc. in a 70 kg (154 pound) man. In moderate shock there is from twenty to thirty per cent loss represent ing a decrease of 1100 to 1700 cc. and in severe shock with blood losses from thirty to fifty per cent or more 2000 to 3000 cc need to be replaced Randall[13] concludes "It seems likely that, from the clinical standpoint there is reason for the use of oral and parenteral fluids, in addition to blood or blood substitutes, in the treatment of hemorrhagic and traumatic shock The extracellular fluid is effectively depleted either through localization in a third space area of trauma or by external loss and restora tion to maintain normal volume is logical In addition, patients surviving shock have definite baseline requirements of water which must be met In dogs, at least, and probably in man the administration of fluid and electrolytes of the extracellular fluid type may accelerate compensation of the circulating volume. The use of oral hypotonic saline-bicar bonate mixtures may form an essential part of the treatment of mass casualties in the event of a major disaster"

According to Fine,[6] "Intravenous saline is better than nothing at all, but

not much better except when there is an existing need for the correction of an extravascular deficit arising from dehydration." This is in variance with the recommendation of Fox[a] who from his animal experiments advocates large amounts even up to ten per cent of body weight, with balanced salt solutions. Fine[6a] further recommends "Oral saline is satisfactory for salt and water deficit due to burns when there is no shock or when there is only mild shock. When shock is overt, intestinal absorption is deficient, and the fluid may remain in the gut or be vomited and aspirated. It may therefore be harmful, even dangerous rather than helpful."

It has been known that infection may lead to profound shock. The following factors may be concerned as summed up by Altemeier.[1]

"1. Loss of fluid from the circulation with diminished blood volume and hemoconcentration.

"2. A disparity between the circulatory blood volume and the size of the vascular bed may also be caused by an uncompensated increase in the size of the vascular bed.

"3. Circulatory failure due to a profound toxemia and direct action upon the heart.

"4. Toxic effect of the infection on the adrenal glands.

"The acute infection which may produce this syndrome include those produced by Cl. *welchii*, hemolytic streptococci, hemolytic staphylococci, pneumobacilli, meningococci, gram negative bacilli, and a mixed bacterial flora."

In the preantibiotic era overwhelming sepsis was a familiar form of irreversible shock. Fine[7] points out that the occasional patient in prolonged hemorrhagic shock will die in spite of adequate blood volume replacement.

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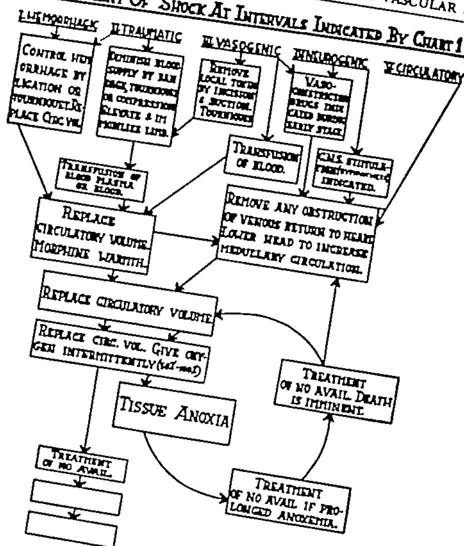


CHART • 3.

(Seeley S F Bull. U S. Army Med Dept. 9 300 [Jan.] 1949)

are the second choice Human albumin is the most effective and safest however on account of its expense and being in short supply this substance cannot meet the demand which might be created by large scale emergency

Plasma so widely used during the past decade carries a definite risk of causing homologous serum jaundice Until methods are evolved to do away with the causative virus its use will decrease

Gelatin is an effective expander but as it gels at room temperature difficulty in flow has been encountered in cold weather Dextran with an average molecular size in the region of 50 000 to 80 000 has been used extensively in Sweden with only a small reaction rate However in this country with certain products the reaction rate has been indeed troublesome Polyvinylpyrroli done a synthetic product developed in

TABLE 1

Summary of Traumatic Shock Cases

Case	*Nature of Injury*	*PVP Given*	*Change in Clinical Status*	*Change in Hematocrit*	*Liver Function Studies*	*End Result and Comment*
I JJ Age 47 Female 52 771	Cerebral concussion. Compounded comminuted fracture of right tibia and fibula. Fracture of left ankle. Multiple lacerations. Shock.	1500 cc. in 3½ hours.	Prompt improvement in blood pressure and pulse as well as other signs of shock.	40% to 31.6% in 3 hours. Rise to 33.5% at 24 hours.	Negative	Discharged to home care on 76th hospital day without complication. Patient carried through operative procedure without use of blood or plasma.
II NT Age 12 Male 52-1399	Severe cerebral concussion and laceration. Fracture of skull, left humerus, left radius and left femur. Traumatic shock.	1000 cc in 4½ hours	Marked improvement in blood pressure, pulse, respiration and general appearance of patient. Patient remained in coma with frequent convulsions for approximately 2 weeks.	40.5% to 22.8% in 4½ hrs. Rise to 28.1% at 21 hours.	Cephalin flocculation 3+ on 2nd day. Negative on 5th day and subsequently	Discharged on 46th hospital day much improved and fractures healing well.
III HW Age [illegible] Male 52 1590	Severe basilar and right posterior parietal skull and mandibular fractures. Traumatic shock.	1000 in 2¼ hours.	Marked improvement in blood pressure and pulse character.	34.6% to [illegible]4.3% in one hour		Patient died 2¼ hours after admission. He was responding to treatment for shock but died an asphyxial death due to aspiration of blood and mucus. Autopsy
IV LT Age 47 Male 52 1661	Penetrating stab wound of abdomen with laceration of liver. Traumatic and hemorrhagic shock.	2000 cc in 5 hours.	Improvement in blood pressure, pulse and other physical signs of shock.	50% to 43.6% in one hour. Rise to 45% in 40 hours	Negative	Hospital course uncomplicated. Discharged in good condition on 16th day. Patient recovered from shock and was carried through general anesthesia and laparotomy without the use of blood or plasma.
V CP Age [illegible] Male 52 11[illegible]	Multiple lacerations of face and extremities with severe hemorrhage. Penetrating stab wound of left chest.	1500 cc in 3 hours	Prompt and sustained improvement in blood pressure, pulse and other vital signs.	32.5% to 23.5% in 3 hours. 21.5% at 24 hours. 22.5% at 73 hours	Questionable positive cephalin flocculation on 15th hospital day	Discharged in good condition on 3[illegible]nd hospital day. Patient was kept in hospital to observe the course of severe secondary anemia following loss of blood. No transfusion given but patient was improving steadily at time of discharge.

(C[illegible], J.W.S., Saris, J. & Scudder, J. Surg. Gyn. & Obst. Sept. 1953. In Print.)

TREATMENT OF SHOCK AT INTERVALS INDICATED BY CHART 1

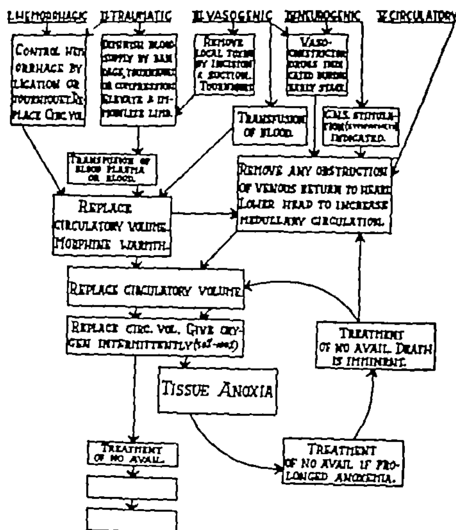


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II NT Age 12 Male 52-1399	Severe cerebral concussion and laceration. Fracture of skull, left humerus, left radius and left femur. Traumatic shock.	1000 cc. in 4½ hours.	Marked improvement in blood pressure, pulse, respiration and general appearance of patient. Patient remained in coma with frequent convulsions for approximately 2 weeks.	40.8% to 22.5% in 4½ hrs. Rise to 28.1% at 21 hours.	Cephalin flocculation 3+ on 2nd day. Negative on 5th day and subsequently	Discharged on 46th hospital day much improved and fractures healing well.
III HB Age 25 Male 52-1520	Severe basilar and *right posterior* parietal skull and mandibular fractures. Traumatic shock.	1000 cc. in 2½ hours.	Marked improvement *in blood pressure* and pulse character	34.0% to 25.5% *in* one hour		Patient died 2½ hours after admission. He was responding to treatment for shock, but died an asphyxial death due to aspiration of blood and mucus. Autopsy
IV LT Age 47 Male 52-1664	Penetrating stab wound of abdomen with laceration of liver. Traumatic and hemorrhagic shock.	2000 cc. in 3 hours.	Improvement in blood pressure, pulse, and other physical signs of shock.	50% to 43.0% in one hour. Rise to 45% in *40 hours.*	Negative	Hospital course uncomplicated. Discharged in good condition on 16th day. Patient recovered from shock and *was carried through* general anesthesia and laparotomy without the use of blood or plasma.
V CP Age 58 Male 52-115	Multiple lacerations of body and extremities with severe hemorrhage. Penetrating stab wound of left anterior chest.	1500 cc. in 3 hours.	Prompt and sustained improvement in blood pressure, pulse and other vital signs.	32.5% to 23.5% in 3 hours. 4.5% at 24 hours. 22.5% at 73 hours.	Questionable positive cephalin flocculation on 15th hospital day	Discharged in good condition on 32nd hospital day. Patient was kept in hospital to observe the course of severe secondary anemia following loss of blood. No transfusion was given but patient was improving steadily at time of discharge.

(Cordice, J W V., Stern, J & Scudder J Surg., Gyn. & Obst., Sept. 1953 *In Print.*)

TABLE 1 *(Continued)*

Case	*Nature of Injury*	*PVP Given*	*Changes in Clinical Status*	*Change in Hematocrit*	*Liver Function Studies*	*End Result and Comment*
VI BB Age 42 Male 52-5057	Laceration of temporal artery with severe hemorrhage. Hemorrhagic shock.	2500 cc. in 3 hours.	Immediate improvement in blood pressure with secondary fall with administration of 100 mg. of demerol for sedation about 1¼ hours after starting treatment. Further improvement in pressure pulse and general condition of pt. upon further PVP administration.	42.9% to 27.8% in 4¼ hours. Rise to 32.7% at 23¼ hours.	Cephalin flocculation 3+ on day of admission	Discharged in good condition on 21st hospital day. Positive cephalin not attributable to PVP since initial blood was taken before administration of PVP and subsequent tests were improved and negative.
VII LA Age 52 Male 52-5559	Penetrating stab wound of abdomen with laceration of liver. Traumatic shock and hemorrhagic shock.	1000 cc. in 45 minutes.	Prompt and sustained recovery from shock.	40.9% to 34.1% in one hour. Rise to 35% at 6 hours.	Negative	Anesthetic death during laparotomy 15 hours after admission. Response to shock treatment good. Death due to causes unrelated to PVP.
VIII DA Age 45 Male 52-5670	Cerebral concussion. Compound fracture of right tibia and fibula. Fracture of right radius. Multiple contusions and lacerations of scalp and extremities. Traumatic and hemorrhagic shock.	1500 cc. in 1¼ hours.	Prompt and sustained recovery from shock.	46.5% to 31.1% in 3 hours. Rise to 33.7% at 24 hours.	Negative	Discharged on 97th hospital day in good condition.
IX RG Age 59 Female 52-5871	Multiple penetrating stab wounds of the chest. Left hemopneumothorax. Hemorrhagic and traumatic shock.	2500 cc. in one hour	Prompt improvement but not complete recovery from shock in time of administration of PVP. Blood pressure rose from 40/0 to 84/52 and the pulse which was initially imperceptible was 114 per minute and of fair quality.	42.9% to 21% in one hour. Rise to 31.1% in 12 hours.	Negative	Discharged in good condition on 14th hospital day. Patient was responding to shock treatment but because it was felt that she was having dangerous bleeding from splenic injury blood was given as soon as it was obtained.
X JD Age 44 Male	Laceration of right forearm and left face with severe hemorrhage. Shock.	1200 cc. in 2 hours.	Prompt and sustained recovery from shock. Because of severe pallor and continued restlessness, though blood pressure was 100/60, 500 cc. of blood were given after PVP. Pt. improved further after blood.	35.5% to 24.4% in 2 hours. Rise to 27% at 24 hours.	Negative	Discharged on 5th hospital day in good condition.

Germany has been used in thousands of cases during World War II with good results and with no reaction. The second part of this article deals with our experience in cases of hemorrhagic and traumatic shock.

Polyvinylpyrrolidone In the Treatment of Shock

Polyvinylpyrrolidone a liquid plastic, used extensively during World War II by the Germans, who first synthesized this from acetylene and formaldehyde, has been undergoing trial in the United States It is dispensed as PVP Macrose by Schenley Laboratories as a 3.5 per cent solution in Ringers. In traumatic and hemorrhage shock, Schulz[15a] has recommended periston* during the first twelve to twenty-four hours In burns he urged its use during the period of hemoconcentration. The solution builds blood volume rapidly and hence will tide a case over the time until properly cross matched blood is made available

Cordice[3] studied thirty-four cases of shock due to hemorrhage and trauma at the Harlem Hospital. Controlled observations on vital signs, blood pressure and pulse rates, as well as the hematocrit and specific gravity of plasma and peripheral blood were recorded before and after infusions of PVP in a group of ten patients The types of injuries in these patients studied in detail varied from pure hemorrhagic shock (laceration of temporal artery) to traumatic shock following severe multiple wounds and fracture. Two had penetrating wounds of the chest four had cerebral concussion in addition to fractures of the skull, or extremities and in two the abdominal wound was complicated with laceration of the liver On admission all were in moderate or profound shock.

* German name for PVP

TABLE 2

Case V., Male Age 38—Multiple Lacerations of Body and Extremities Severe Hemorrhage from Laceration of Biceps Muscle and Brachial Veins. (Estimated Blood Loss 1200 cc.) Penetrating Stab Wound of the Left Anterior Chest (Minimal) With Fracture of the Left Fourth Rib Anteriorly

	PRE PVP	TIME—POST PVP						
		1 Hour	3 Hours	6 Hours	12 Hours	24 Hours	72 Hours	121 Hours
Hemoglobin				42%		44%	42%	44%
Hematocrit	32.5	31.5	23.5	23.3	22.9	24.5	22.5	25
Plasma Protein Gm. %						Alb. 5.4 Glob. 1.9 Total 5.3		
Plasma Sp. Gr.	1.0211	1.0202	1.0200	1.0192	1.0197	1.0214	1.0226	1.0244
Whole Blood Sp. Gr. Capillary	1.0423	1.0371	1.0352	1.0345	1.0335	1.0394	1.0358	1.0409
Venous	1.0392	1.0354	1.0342	1.0340	1.0332	1.0391	1.0353	1.0407
Blood Pressure	0/0	104/60	105/65	100/60	125/70	140/100	100/60	125/80
Pulse	Imperceptible	78	70	85	100	100	85	84

(Cordice, J W V., Soen, J & Scudder J Surg., Gyn. & Obst., Sept. 1953 In Print.)

TABLE 3

CASES OF TRAUMATIC AND HEMORRHAGIC SHOCK TREATED WITH PVP

Case	*Nature of Injury Date*	*General Condition Before and After PVP*	*Blood Pressure Before After*	*Pulse Before After*	*Reaction Result*
1 CB Age 50 Male	Laceration of scalp. 1/19/52	Mild shock secondary to hemorrhage. Improved after 1000 cc. of PVP	80/40 110/80	118 100	None Improved Discharged
2 JB Age 36 Male	Stab wound of chest, non-penetrating. 3/29/52	Shock secondary to hemorrhage and trauma. Improved after 500 cc. of PVP	80/50 100/60	120 108	None Improved Discharged
3 MC Age 23 Female	Lacerations of right breast and left posterior chest. 4/12/52	Moderate shock secondary to hemorrhage and trauma. Improved after 500 cc of PVP	70/30 108/60	118 104	None Improved Discharged
4 RE Age ? Female	Laceration of left wrist. 3/18/52	Mild shock secondary to hemorrhage. Improved after 500 cc. of PVP	78/50 100/80	100 96	None Improved Discharged
5 BE Age 25 Female 52 7591	Stab wound of chest multiple lacerations. 4/29/52	Moderate shock secondary to trauma and hemorrhage Improved after 500 cc. of PVP	80/40 120/80	120 100	None Improved Discharged
6 AF Age 46 Male	Laceration of scalp. 3/23/52	Mild shock secondary to hemorrhage Improved after 500 cc. of PVP	88/40 100/80	124 109	None Improved Discharged
7 SF Age 44 Male	Laceration of right chest abdomen, left hand and chin. 4/18/52	Moderate shock secondary to trauma and hemorrhage Improved after 1000 cc. of PVP	78/50 109/78	118 104	None Improved Discharged
8 AG Age 43 Male 52-8334	Penetrating gunshot wound of abdomen with injury to bladder and extensive laceration, and fracture of pelvis. 5/30/52	Severe shock secondary to trauma and hemorrhage. Improved after 1000 cc. of PVP Immediate surgical exploration with use of 1000 cc. of whole blood.	70/0 100/60	124 110	None Improved Discharged
9 NG Age 32 Male	Laceration of right ear 5/2/52	Mild shock secondary to trauma and hemorrhage. Improved after 500 cc. of PVP	80/30 100/60	128 112	None Improved Discharged
10 JC Age 31 Male	Laceration of scalp. 2/12/52	Mild shock secondary to hemorrhage Improved after 500 cc of PVP	80/60 120/70	114 96	None Improved Discharged
11 WE Age 55 Male	Laceration of scalp. 4/8/52	Moderate shock secondary to hemorrhage Improved after 1000 cc. of PVP	78/30 114/80	118 89	None Improved Discharged
12 LM Age 41 Female Female	Stab wound of chest, non-penetrating, and multiple lacerations.	Mild shock secondary to hemorrhage and trauma Improved after 500 cc of PVP	60/36 120/74	122 92	None Improved Discharged

(Cordice J W V., Soesa, J & Scudder J Surg Gyn. & Obst., Sept. 1953 In Print.)

TABLE 3 (*Continued*)

Case	*Nature of Injury Date*	*General Condition Before and After PVP*	*Blood Pressure Before After*	*Pulse Before After*	*Reaction Result*
13 GI Age 50 Female 52-0326	Cerebral concussion. Fracture of right femur. Bilateral fractures of both pubic rami.	Severe shock secondary to trauma and hemorrhage. Improved after 1000 cc. of PVP 1000 cc. of whole blood followed.	40/0 118/76	122 88	None Improved Discharged
14 SJ Age 19 Male 52-10683	Stab wound of the heart. 6/20/52	Severe shock secondary to trauma and cardiac tamponade Improved after 500 cc. PVP 500 cc. of plasma and 500 cc. of whole blood followed. Immediate thoracotomy with repair of wound of right ventricle.	60/0 120/78	Imperceptible 88 (at end of operation)	None Improved Discharged
15 WJ Age 33 Male	Laceration of neck. 1/18/52	Moderate shock secondary to hemorrhage. Improved after 1000 cc. of PVP	70/0 100/80	128 96	None Improved Discharged
16 EM Age 34 Female	Laceration of buttocks. 2/18/52	Mild shock secondary to trauma and hemorrhage Infusion after 500 cc. of PVP	90/40 120/70	118 96	None Improved Discharged
17 JQ Age 44 Male	Laceration of neck and left ear 2/15/52	Mild shock secondary to trauma and hemorrhage. Improved after 500 cc. of PVP	88/44 100/80	112 88	None Improved Discharged
18 HR Age 34 Male 52 7827	Cerebral concussion and fracture of acetabulum. 5/3/52	Moderate shock secondary to trauma. Improved after 1000 cc. of PVP	80/50 130/80	110 100	None Improved Discharged
19 SS Age 38 Male 52-9695	Cerebral concussion. Compound fracture of left tibia and fibula. 6/5/52	Moderate shock secondary to trauma and hemorrhage Improved after 1000 cc. of PVP	78/40 125/75	105 100	None Improved Discharged
20 CT Age 60 Female	Stab wound of back. Laceration of scalp. 2/4/52	Moderate shock secondary to trauma and hemorrhage. Improved after 500 cc. of PVP	90/44 110/70	118 94	None Improved Discharged
21 LT Age 26 Male 52-0353	Stab wound of pericardium. 3/31/52	Marked shock secondary to trauma and hemorrhage. Improved following 1000 cc. of PVP. 500 cc. of plasma and 500 cc. of whole blood followed. Immediate thoracotomy with exploration of the wound.	60/40 110/60	100 112	None Patient died on 4th postoperative day from acute fulminating empyema, pericarditis and heart failure
22 AT Age 30 Male	Laceration of right thigh. 2/26/52	Mild shock secondary to trauma and hemorrhage. Improved following 500 cc. of PVP	98/80 118/80	108 92	None Improved Discharged
23 CT Age 26 Male	Laceration of face, neck and back. 2/2/52	Mild shock secondary to trauma and hemorrhage. Improved after 1000 cc. of PVP	80/40 110/70	108 88	None Improved Discharged
24 VU Age 37 Female 5 10114	Cerebral concussion. Fracture of body of L-2. Fracture of left talus. 6/11/52	Severe shock secondary to trauma. Improved after 1000 cc. of PVP	0/0 110/80	Imperceptible 80	None Improved Discharged

Patients not admitted to the hospital were treated on the accident ward and referred to the out patient clinic for follow-up.

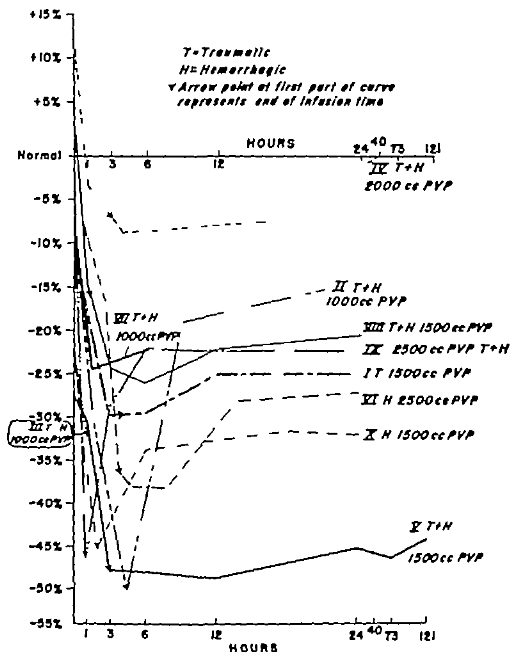


FIG. 3 (Cordice, J. W. V., Suess, J., and Scudder J. Surg., Gyn., & Obstet. [Sept.] 1953.)

Cases I and IV after recovery from shock, were successfully carried through operation with PVP as the only infusion.

One representative case is cited to show the efficacy of PVP in treating hemorrhagic shock from a severed brachial vein. On admission the blood pressure was unobtainable Bleeding was controlled with clamps and 500 cc of PVP were injected in thirty minutes with the blood pressure rising to 70/40 and the pulse rate being countable at 80 Within the first hour a second unit of PVP was completed with the blood pressure now at 104/60 and pulse 78 There was bleeding from the brachial wound at this time requiring sutures Three hours after admission the third bottle of PVP was completed The patient was out of shock with a blood pressure of 110/78 and pulse rate of 68 During the subsequent course in the hospital, no blood or plasma was given In three cases in which blood was purposely withheld to observe the course of these untransfused patients no complications occurred.

Objective measurements, indicating that hemodilution was secured, were observed in the significant decrease in the venous hematocrit and in the specific gravity of plasma and that of peripheral capillary blood.

There was prompt and sustained improvement from shock in all. There were two deaths one from anesthesia and the second due to aspiration of blood and mucus in a case with severe head injury

Of the twenty four cases of shock studied in the second group who received PVP only eight required admission to the hospital. The other sixteen responded so well to PVP and treatment

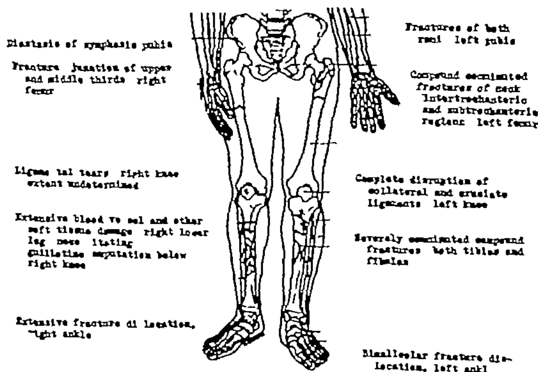


FIG. 4 (Scudder J., Original data. [Nov] 1952.)

METHODIST HOSPITAL

ANESTHESIA RECORD

241004 Levine, Harry — My 18, 1952
Lange — Dr. Detri — Dr. Flowers — White
Multiple fractures, simple and compound, both lower limbs
Same — ① Repair of laceration of left groin with drainage. ② Guillotine amputation of Rt. leg below knee. ③ Application of double hip spica.
49
Morph. gr. 1/6 — 11:20 PM
Atrop. gr. 1/150
Shock, critical — No history or physical. No blood or urine.

$N_2O + O_2 +$ Ether

Ether-oxygen

12:1 AM … 1 AM … 2 AM … 3 AM … 4 AM

G/S
Blood
Blood
Plasma
Blood

Moved from O.R. table to Hawley table

Pale, in shock. Pulse weak.

Blood 2000 cc
Plasma 500 cc
G/S 300 cc
2800 cc

$N_2O + O_2$
$N_2O + O_2$ Ether ℥iii
Critical — Elsa Thelen

Pulse ˅, B.P. ˄, Resp. ●

in the accident ward that they were discharged to the out patient clinic Case 21 was the only mortality and occurred four days after operation

We conclude this chapter with an unusual case illustrating the various points discussed From time immemorial the principle of early succor has been learned by each generation The corpsmen in World War II gave both plasma and blood at the front or at the site of injury This same principle needs to be inculcated for accidents along our highways

"Splint them where they lie" should be modernized to "Support and splint them where they lie"

This policy was again brought into sharp focus when two units of polyvinylpyrrolidone (PVP Macrose) were injected into the veins of an injured automobile driver who was struck by an onrushing car while adjusting a faulty tail light at 10 10 P.M He sustained two compound comminuted fractures one compound dislocation of the head of the left femur five other dislocations and six fractures including the pelvis and both lower extremities Shock supervened from the magnitude of trauma, multiplicity of wounds and hemorrhage

One doctor's belt controlled the bleeding from the left leg morphine was injected by a second physician who stopped to render aid, and the plasma volume extender PVP was begun ten minutes after the crash by a third physician who carried it in his car The infusion of 1000 cc of PVP was given to the patient as he lay on the roadway while awaiting the arrival of the ambulance and splints.

At the time of the venipuncture blood was withdrawn into a test tube and labelled with the patient's name The ambulance attendant was explicitly instructed to deliver this blood at once to the doctor on duty in the emergency ward. He was also given a note stating the time of the accident and what splints had been applied and what support had been given the patient.

On arrival at the Methodist Hospital the intern supplemented the PVP with glucose and saline sent the blood to the Bank for typing and cross-matching called the attending surgeon who "cut red tape" and took the patient immediately* to the operating theatre where under N_2O and O_2 ether anesthesia, the dirty contused, comminuted, compound-fractured lower right leg was amputated by a rapid guillotine operation, and the other fractures and dislocations reduced and immobilized by a double hip spica plaster cast. During this time 2000 cc of type B Rh positive blood and 500 cc of plasma were transfused. The patient left the operating room in a better condition than on arrival, with a blood pressure of 120/70 and a pulse rate of 110 He did not relapse into shock nor did he become oliguric. Postoperatively he was placed on antibiotics

In summarizing this case, the injured received adequate support early: he was splinted before being moved from the highway into the ambulance his blood volume was built up with 1000 cc of PVP before he reached the hospital his progress was sustained by plasma and adequate blood he had the benefits of a rapid operation, immobilization and good nursing care

* Elapsed time between accident and start of operation one hour and fifty minutes.

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SECTION VII

UROLOGICAL EMERGENCIES

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Urological Emergencies

THE results of trauma insofar as the genitourinary tract is concerned are frequently associated with trauma of other organs This fact demands continuous vigilance on the part of the physician when he is confronted with trauma. Blows to the abdomen even though not directly over the area of the kidneys or ureters or bladder may cause injury to these structures

Hematuria the most important single symptom indicating injury to the genitourinary tract, calls for immediate investigation Shock of a severely critical nature is the only contraindication to investigation. After the shock problem is adjusted, the next questions are Can the patient void? Is the urine voided in two portions uniformly bloody? Or is the first portion bloody and the second portion clear? An equally bloody urine in both specimens is indicative of trauma to the bladder or upper urinary tract. Blood in the first specimen and none in the second are of course indicative of injury to the genital tract. Careful observation of the point of entry of a missile or of a bruising trauma in the region of the kidneys or bladder is of value in indicating the likelihood of damage to the respective organs X-rays of the region of the kidneys ureters, and bladder should be done immediately The psoas and soft tissue shadows should be carefully observed. Intravenous urography can be done immediately if shock is not severe and if this is unsatisfactory cystoscopy is immediately indicated if the status of the bladder or the upper urinary tract is indefinite One point that should always be definitely determined, if possible, is that there are two kidneys before one is explored. Insofar as the types of injuries to kidneys are concerned, we arbitrarily divide them into the mild intracapsular and the more serious capsular injuries. In the presence of a proven intracapsular injury the patient should be watched continuously taking hourly blood pressure readings and noticing the nature of the urine With a proven extracapsular lesion the kidney should be explored immediately and appropriate measures followed. If any repair surgery is done on the kidney a urographic follow-up study should be done in order to assure oneself of the status of the kidney before dismissal. Throughout all care of genitourinary trauma, the general measures related to trauma and shock must be followed and will not be enumerated here.

Insofar as prophylaxis against the formation of urinary calculi is concerned, there are several measures which should

be scrupulously followed. First of all, *it is not at all uncommon with patients* who are hospitalized as bed patients for long periods of time and particularly if they are orthopedic patients, to give them large quantities of milk and citrous juices Milk and citrous juices in some individuals are the major etiological factors in stone formation and therefore only small amounts of them should be given Spinach asparagus and rhubarb should be definitely excluded from *the diet* because of their oxalate content In addition to this, a large fluid intake of not less than 2000 cc. and preferably 3000 cc of water per day should be maintained Prophylactic measures against stone formation are *particularly important in the orthopedic* cases with neurogenic bladders This will be commented upon later

When large quantities of antibiotics and chemotherapeutic agents are used, *it not infrequently happens that blood* coagulating factors are adversely influenced and for this reason if bleeding is a problem, vitamin K should be given in dosages of 72 mg intravenously daily until one is assured that adequate vitamin K is present.



FIG. 1 Diagrammatic sketch of intraperitoneal rupture of the bladder (Praiber G C. New York State J Med., 53 318 [Feb 1] 1953)

Ureteral Trauma Insofar as ureteral damage is concerned the principles involved are few and relatively simple First of all, wherever possible *simple* anastomosis of a ureter using but very few approximating small caliber sutures with or without intubation, depending upon the situation, and drainage to the outside are the major technical features to be observed. If the injury is in the region of the bladder and it is possible to put the free end of the ureter into a new position in the bladder this is also a relatively simple mat

ter and should be done by making a stab wound diagonally through the wall of the bladder so as to form a slight valve effect and the ureter should be brought through and fixed to the interior surface of the bladder with either two or four radial flaps. Under these circumstances adequate drainage should be maintained to the external surface of the body In the event that it apears impossible to salvage the ureter and anastomose it or implant it, a ureter may be ligated and dropped back. It is very rare following this procedure that any further difficulty with the kidney develops. In the event that subsequent pyelonephritis, or in most rare instances hydronephrosis should develop it can be appropriately taken care of subsequently

Bladder Where bladder injury occurs, all that is necessary is to be sure good exposure is obtained and the injury to the bladder sutured with chromic catgut, not any larger than No 1 Bladders may be sutured with continuous sutures and through and through suturing is permissible and advisable In closing the bladder a suprapubic cystostomy drain should be left in and this suprapubic drainage tube should be placed as far above the symphysis as possible because of any subsequent necessity of performing cystostomy or cystotomy If this drainage is not put far from the symphysis, it is almost certain that the peritoneal cavity will be entered in subsequent bladder surgery Commenting upon this feature, it is a fact that no single technical surgical aspect has been more frequently violated in military and civilian traumatic problems that the location of the suprapubic drainage tube

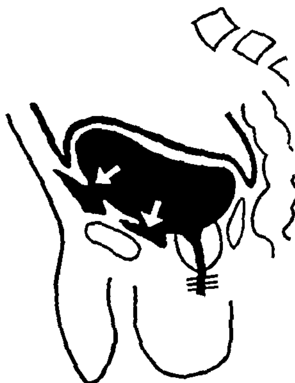


FIG. 2. Diagrammatic sketch of extraperitoneal rupture of the bladder (Prather G C. New York State J Med., 53 318 [Feb 1] 1953)

A Penrose drain should be left in the prevesicle space Insofar as closure of the abdominal wall incision in bladder exposure is concerned, the simplest is the best. The simplest is figure eight using nonabsorbable suture material, beginning the interrupted sutures 37 mm (1½ inches) from the margin of the incision bringing this needle out just drainage tube may be anything from a 20 to a 30 and may be either a straigh catheter or a Foley according to the availability and wishes of the surgeon

Urethral Injury· In urethral injury when the patient is unable to void a successful passage of a No 20 catheter is a very happy initial procedure When this is done this catheter should be lef



FIG. 3 Cystogram via intravenous urogram which gives no indication of rupture indication of rupture of bladder (Prather G C New York State J Med 53 318 (Feb 11 1953)

above the fascia on the same side, then introducing the needle in the fascia on the opposite side then bringing it under and through the fascia of the original side and across and out 37 mm (1½ inches) from the skin margin on the opposite side When these sutures placed at intervals of 2.5 cm (1 inch) are tied the entire abdominal wall is approximated and no appreciable amount of absorbable suture material is left in the incision This type of closure results in the best wound healing there is for bladder surgery The size catheter left as a suprapubic cystostomy in place and not removed If unable to pass a urethral catheter then either a perineal or suprapubic approach may be made and immediate anastomosis over a catheter done through a combined suprapubic and perineal incision or a simple perineal closure if this is technically possible If urethral damage has been present for a matter of some hours and marked extravasation has occurred, multiple incisions are indicated in the region of the scrotum, perineum and lower abdomen. Following these extravasations vigorous support is very necessary and in these days, very satisfactory

Scrotal Injuries Scrotal injuries should always be handled conservatively because the potentialities of plastic procedures are so frequently successful even when large quantities of scrotum may be missing that castration should not be done hurriedly

Incisions. If the objective is one of the renal area alone, the most popular the bladder incision it is worthwhile repeating because of its importance to be sure that the cystostomy tube be placed as far away from the symphysis pubis as possible. The reason for this is to insure the surgeon who opens the bladder subsequently for any reason whatsoever against getting into the peritoneal cavity



FIG 4 Retrograde cystogram of same patient as in Fig. 3 demonstrates intraperitoneal rupture of bladder (Prather G C., New York State J Med., 53 318 [Feb 1] 1953)

and best incision is one which is laid out by bisecting the angle between the lower border of the last rib and the spine and bisecting the distance between the crest of the ilium and the lower rib A curved incision connecting these bisections is the line of incision most appropriate In the event that abdominal exploration should be necessary the anterior portion of this incision can be extended as far as one wishes. Insofar as mixed urinary tract and abdominal trauma is concerned, there is too wide a selection to advise any one particular type For most bladder work a low midline incision is best. In consideration of

Regardless as to what location one explores there should be handy large goiter rolls of gauze and large numbers of different sized packs The reason for this is the effectiveness of their use when encountering brisk hemorrhage which cannot be immediately controlled and which if not controlled would considerably increase the hazard of hemorrhage

Neurogenic Bladder The problem of the neurogenic bladder in traumatic cases is a most important one and one which is very frequently incorrectly treated The following quotation from Frank Hinman is most appropriate

"Care of the paralytic bladder is a grave responsibility In the War of 1914 to 1918 about eight out of every ten American soldiers sustaining injuries to the spinal cord which gave rise to a paralytic bladder died from this cause rather than from the injury Death was caused by renal sepsis and decubital ulcers and the fundamental basis of the teaching of this field is to reduce these hazards to a minimum"

clinical observation is not by any means uniform in everyone The nerves involved in the bladder mixture are the sympathetic nerves (hypogastric from the lumbar segment of the spinal cord) the parasympathetic nerves (pelvic from sacral segment) and the somatic nerves (pubic from sacral segment)

The cardinal objective in the management of a neurogenic bladder is to insure against distention from the ear



FIG. 5 Retrograde cystogram shows intraperitoneal rupture of bladder (Prather G C, New York State J Med., 53 318 [Feb. 1] 1953)

liest phases Urethral catheter drainage rather than intermittent catheterization is essential In the event that urethral catheters are not tolerated, suprapubic cystostomy should be instituted Some injuries are of very short duration and some are permanent. The clinical course of these cases depends in great measure upon the proportion of the nerve injury Neuromuscular dysfunction will persist from a period of a few days to a period of some months depending upon the nature of the injury

A break in methodical care no matter how short, frequently means disaster There can be no set rule of treatment. The method must vary with the circumstances The physiology of the bladder is basically one of continued variable balance between the contraction function of the bladder muscle wall and the sphincteric action at the outlet of the bladder The balance between these two muscle tensions is the mechanism which produces bladder physiology The nerve supply is mixed and according to

The status of the bladder wall is very simply tested by running in small quantities of irrigation fluid, preferably normal saline solution, and observing whether there is any pressure from the fluid instilled Under no circumstances should large quantities of residual fluid be allowed to occur After satisfactory or cutaneous ureterostomy Cutaneous ureterostomy is indicated because of the fact that if the bladder function is disturbed to a sufficient degree to call for diversion of the urinary stream from the bladder it is usually equally unsatisfactory to put the ureters in the bowel because of an accompanying and coinci-



FIG 6 Retrograde cystogram shows extraperitoneal rupture of bladder (Prather G C, New York State J Med., 53 318 [Feb. 1] 1953)

drainage has been maintained for a period of a month, trial and failure observations following the administration of such substances as mecholyl, belladonna, ephedrine, prostigmine and combinations of these substances injection of (1) the pudendal, (2) the pubic, or (3) the second and third sacral nerves may be tried to determine the influences of these different measures In the event that none of these measures proves successful, the final solution resolves itself into suprapubic cystostomy dental bowel problem. If cutaneous ureterostomy is indicated, a recent technic described by Talbott, in which he makes cutaneous finger like projections through which the ureter passes makes management of ureterostomy much more satisfactory In situations where it seems possible that removal of a portion of the prostate will allow complete emptying, transurethral resection many times proves a very satisfactory procedure. Sometimes this has to be done in stages in an attempt to prevent in-

continence and at the same time result in complete emptying. All mechanical drainage technics demand appropriate chemotherapeutic or antibiotic therapy associated with general metabolic support. The most unsatisfactory problems are those in which stone formation occurs as a result of this uncontrolled infection. Fortunately these cases on a percentage basis are few. All neurogenic bladder cases resolve themselves into individual problems since there are no two cases which are identical. It is for this reason that individualization is necessary and calls for so much trial and failure in therapeutic regimens.

SECTION VIII

ACUTE SURGICAL PROBLEMS THE RESULT OF UNFORESEEN COMPLICATIONS

J D MARTIN JR., M.D *

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Postoperative Hemorrhage

HEMORRHAGE has long been recognized as one of the paramount problems in operative surgery Much progress has been made in the prevention of bleeding, both during the procedure and in the immediate postoperative period. However it continues to be one of the great causes of morbidity and a major factor in the postoperative mortality

Prevention of this complication is more important than attempting some heroic measure after it has occurred. This can be accomplished by careful planning before the procedure is undertaken. Adherence to the basic principles of good surgery are excellent prophylactic measures. Complete relaxation adequate exposure of the operative field, and utilization of sufficient technical assistance are essentials It is obvious that, without a thorough appreciation of the anatomical arrangement, the dangers are manifold. Careful dissection, with the avoidance of unnecessary trauma during the procedure, will be rewarded in lessening this unnecessary problem. Ligation of individual vessels must be done rather than mass ligature. This can be accomplished only when each individual area is carefully dissected regardless of the location and apparent minimal vascularity The electrocoagulation for control of bleeding is of extreme value in the smaller vessels. In those of any magnitude, it is well to remember that coagulation of a large vessel may be followed by bleeding, after the destroyed area separates during the process of repair It is best that these arteries and veins be ligated securely rather than coagulated Many arteries should be doubly ligated and the larger ones controlled by suture The fixation suture should be placed to avoid (Fig. 1) direct trauma to the artery Simple penetration of a large artery may result in immediate bleeding through the puncture wound with extravasation of blood into the adjacent area. This will produce a hematoma which may develop an aneurysm. Elkin[1] has shown that arteriovenous fistulae are accidentally produced in the course of a surgical procedure. It is believed that these occur when an artery and vein are penetrated with a suture or when a mass ligature incorporates both structures.

Gelfoam, oxycel, or plain gauze may be of considerable value in controlling postoperative oozing from the surfaces of viscera, when ligation of each individual vessel cannot be accomplished. It should be remembered that neither of

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these methods is a substitute for a completely dry field accomplished by ligation of each vessel.

The incision is the commonest site of postoperative bleeding in abdominal operations. Careful control of all bleeding on opening the abdomen is not only desirable, but essential. There frequently continues to be an ooze even with care both during the procedure and at the termination of the operation. A rapidly developed hematoma may account for wound infection which interferes with the process of healing. This is accepted as one of the important factors in causing dehiscence or an incisional hernia. In prolonged operations, the use of retractors traumatizes the vessels of the abdominal wall and thus permits immediate extravasation of blood; tissue damage is also produced. Delayed hemorrhage could be avoided by having an adequate incision which obviates prolonged and unnecessary retraction. When such occurs it should be recognized at the time of operation and the injured vessel should be dissected free. Any hematoma should be evacuated and the vessels securely ligated.

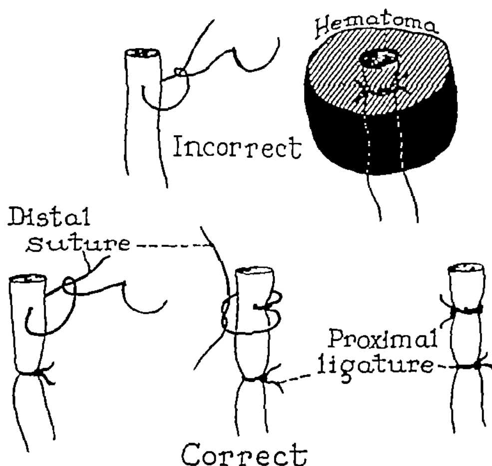


FIG. 1. Method of placing a fixation suture through a blood vessel. This demonstrates the development of a hematoma, which can be an aneurysm.

Many attempts[2,3] have been made to correlate coagulability of the blood with

operation and anesthesia. At present, there are no proven disturbances in the clotting mechanisms as a result of anesthesia.[4] It is well known that, in the presence of jaundice, the prothrombin levels are further lowered during anesthesia this accounts for the inadequate clot formation During the first stage of inhalation anesthesia there may be an appreciable temporary increase in the bleeding There are perhaps unknown factors which in rare instances alter the hemostatic mechanism Recent evidence[5] indicates an associated hormonal influence in the coagulability of the blood

The use of any drain for long periods may produce an erosion of one of the major vessels of the abdominal wall. The ones most frequently injured are the superficial circumflex iliac and the superior or inferior epigastric Associated infection with prolonged drainage plays a major role in such an occurrence At present, this complication is rare since prolonged drainage is seldom necessary However when erosion does occur the drains should be removed and the vessels secured.

Instances have been noted when post operative bleeding from the wound occurs, yet, at reoperation, no definite bleeding points can be located. Control of bleeding can only be readily accomplished by pressure or some type of packing

Retroperitoneal hemorrhage remains one of the difficult problems and may become catastrophic. A major vessel may be torn with even minimal indirect trauma. This is followed by massive retroperitoneal bleeding Some injury takes place during the manipulation of the bowel but should be limited in its scope The use of deep retractors applied overenthusiastically may be cause of such damage. The occurrence is usually recognized at the time but frequently it is overlooked until late manifestations develop The immediate findings are not those of acute blood loss but may be an unexplained fever or an undue postoperative distention Following traumatic retroperitoneal bleeding, the course is very severe and may result in a fatality if unrecognized When a large retroperitoneal hematoma becomes infected, the prognosis is graver This is due in part to the difficulty of localizing the abscess and instituting satisfactory drainage

When abnormal bleeding is encountered at the time of operative procedure there is a great tendency to explain this by some derangement of the clotting mechanism. It is obvious that individuals with these conditions should be carefully evaluated prior to elective surgery and in the presence of abnormalities attempts at corrections should be instituted. This cannot be accomplished in an emergency and bleeding difficulties may be expected or following an operation. The presence of chronic liver disease, either with or without jaundice should be viewed with much caution since liver functions are both directly and indirectly correlated in the mechanism of blood clotting.

The bleeding that occurs during operation may be obvious and is easy to recognize However treatment may be difficult and require all the facilities available to recover from the hemorrhage Diagnosis in the postoperative period presents the necessity of differentiation from less critical causes of shock. The first requisite is an understanding and awareness of the condition in order that early treatment may be rendered

Hemorrhage from one of the major

vessels is a precipitous affair the correction of which is essential at the time it becomes manifested. Unfortunately it occasionally is not obvious during the operative procedure but occurs as a delayed consequence This is frequently not recognized and may result in a fatal issue. Vessels in and around the intestine may be severed and retract into the mesentery thereby producing a massive hematoma which encroaches on the blood supply to the involved segment and eventually produces necrosis. When this occurs, resection of the devitalized intestine is required However an immediate evacuation of the hematoma and ligation of the individual vessels may prevent the necessity of later resection of the bowel In most instances, the ligature must be placed both proximal and distal to the site of the injury if bleeding is to be adequately controlled.

The pedicle of the solid viscera may be torn and become a major source of bleeding. The splenic vessels are easily damaged during a gastrectomy when traction is exerted on the remaining segment of stomach. A subdiaphragmatic hematoma may not be recognized until signs of sepsis or a subdiaphragmatic abscess is evident As a prophylactic measure it is recommended that an inspection be made at the termination of each operation and in some instances, irrigation with warm saline may be effective in demonstrating bleeding which otherwise would be overlooked

The operative attempt to control bleeding can be more disastrous than the hemorrhage Major ducts or viscera may be injured in a hurried effort to arrest the hemorrhage During operations on the gallbladder and stomach, the common bile or pancreatic ducts may be clamped or divided. A retracted bleeding vessel from the pedicle of the right kidney may result in injury to the vena cava and second portion of the duodenum since they are in such a position to be damaged. When hemorrhage occurs from an artery or vein, every effort is directed to stop the bleeding immediately There is a great urge rapidly to apply a clamp to the bleeding point without regard to the adjacent structures that may be secondarily injured. If a deliberate, but unhurried, approach is made, this hemorrhage can be controlled without an unfortunate injury to other structures Accurate knowledge of the detailed anatomy of the blood supply as well as the variables in the entrance of the cystic duct into the common duct are most essential. The recognition of these should be a requisite before attempting control of the bleeding.

During the course of operation on the gallbladder the cystic artery affords an excellent opportunity for being damaged. The critical area at the junction of the cystic and common ducts must be carefully dissected and appreciated before the operation is undertaken. The cystic duct must be separately visualized and carefully dissected from the common duct before clamps are placed. Undue traction on the gallbladder in an attempt to obtain a better exposure may tear or otherwise injure the blood supply Dissection of the cystic artery either before or after it divides into the superior and inferior branches must be carefully made to avoid injury to all of the nearby structures Before undertaking any surgical operation within this or other areas of the abdomen, there must be adequate exposure and complete relaxation, without reliance upon undue traction or retraction Anesthesia should

afford complete relaxation to obtain better visualization.

Ligation of the cystic artery and veins should be accomplished before the dissection of the gallbladder from the liver It is to be remembered that the main blood supply of the right lobe of the liver may be in close proximity to the cease bleeding However it is necessary that a careful dissection be made and that the severed ends of the vessel be recognized and separately doubly ligated In this manner only can an accident be avoided, which occurs too often during the anxious effort to control bleeding.



FIG. — Drawing demonstrating method of inserting index finger in the foramen of Winslow to control the blood supply to the gallbladder following uncontrolled bleeding.

cystic artery and moreover may be included when mass ligatures are applied. If the cystic artery or one of the anomalous branches are uncontrolled, it is recommended that the vessel be allowed to bleed until the left index finger can be placed through the foramen of Winslow and compress the major vessels in the gastrohepatic ligament bleeding can be temporarily controlled. Following the manipulation (Fig. 2) it has been seen in many instances that small vessels

Injury to the common and hepatic ducts also occur when undue traction is placed on the cystic duct and a portion of the wall of the duct is included in the ligature Opportunity is also afforded for injury when the ligature slips from these structures and an effort to replace them hastily is made. It cannot be too strongly emphasized that careful dissection, visualization, and individual ligation are necessary

When an accident of this type occurs,

excitement should be avoided but all maternal aid must be available for recovering from sudden hemorrhage namely immediate pressure control of the bleeding point constant suction and the careful dissection and application of a clamp only to the bleeding vessel. If one keeps in mind that there is a constant variation in the normal structures, many of these unfortunate accidents can be avoided.

It has been well recognized that the ureters may be ligated severed or otherwise traumatized, during both abdominal or pelvic procedures. *It is most often damaged during hysterectomy since the uterine artery is in close proximity to the ureter as it passes near the lower uterine segment.* This injury can be avoided by a careful dissection individual ligation of the uterine artery as it enters the uterus and by avoiding the parametrial tissues near the entrance *of the uterine artery into the bladder* A ligature may be displaced from a uterine artery with a retraction of the vessel beneath the ureter This affords ample opportunity for clamping and *ligation in the effort to control the* bleeding rapidly The same preventive measures are essential such as, careful unhurried dissection and control of the individual vessels

Diagnosis of the obvious external bleeding both during and after operation requires no comment but the failure to respond and to institute necessary treatment before the patient has become depleted of the major portion of the blood volume may be disastrous The recognition of concealed hemorrhage postoperatively requires considerable alertness *This is accomplished by constant vigilance and awareness of the condition in the patient who does not do well for the first few hours* The first symptoms may be a persistent, rapid pulse with a normal blood pressure which later drops as the hemorrhage progresses. Sudden massive bleeding, may be obvious with extreme thirst, nausea, pallor and hypotension.

Added difficulties are encountered when massive transfusions are necessary for uncontrolled bleeding Small multiple hemorrhages occur throughout the operative field. The clotting mechanism is disturbed if a larger percentage of the patient's blood has been replaced by stored blood which contains diminished or absent platelets *This* can be a problem after prolonged hemorrhage which is not satisfactorily controlled by early ligation and blood replacement.

If in spite of adequate transfusions, response is not rapid, immediate exploration is in order This is a difficult decision and rests entirely on clinical judgment, necessitating immediate treatment *if death is to be prevented* Laboratory examinations are valuable both in determining the degree of hemorrhage and as an aid in controlling the amount of replacement therapy *They are not always necessary however to establish* the diagnosis of massive blood loss.

Prevention of overloading an already damaged circulatory system, is a caution to be observed *This difficulty is seldom a factor when massive bleeding has occured* Where patients are continuing to bleed, in spite of treatment, the blood pressure and general condition cannot be completely *returned* before a safe operative procedure can be undertaken Recently this has been made possible by knowing exactly how much replacement is necessary *rapidly giving sufficient intra arterial* blood and immediately reopening the abdomen and controlling the bleeding without delay Arterial transfusion[6] has now become a standard pro-

cedure and should be utilized in these extreme cases. The decision for reoperation is difficult but it is always unwise to procrastinate hoping that an improvement will take place and reexploration can be avoided. It is felt that it takes more courage not to open the abdominal cavity than to do so when patients are apparently bleeding. This is particularly true since the facilities for replacing blood have become universal.

Speed is seldom necessary in the surgical procedures since anesthesia has become more safe and the preoperative preparation much more complete. There was perhaps a real need for speed when time played a significant part in recovery of the patient. This is not true at the present and it is felt that many of the accidents which formerly were prevalent can be avoided by deliberate approach with the essentials of good safe surgery being utilized. If an adequate plan has been made, with full recognition that this may be discarded at any moment, these difficulties can be avoided. The utilization of all available means for the performance of surgery will be beneficial in lessening the complications which heretofore have been in evidence. There will be some accidents which will occur even in spite of all precautions. It is essential that all available aids be instituted prior to the time of operation in order that recovery may be complete with least residual effects.

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S ARTHUR LOCALIO M D *

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Wound Disruption

WOUND disruption is a serious complication for the patient and a disconcerting experience for the surgeon. The terms disruption, dehiscence and evisceration are used rather loosely and interchangeably to connote different degrees of failure of an abdominal wound to heal Disruption defined as the state of being rent asunder and dehiscence defined as the act of splitting can be used synonymously to describe separation of all the layers of the abdominal wall including or excluding the skin If all of the layers of the abdominal wall have separated and in addition there is protrusion of abdominal viscera on the surface of the abdomen we then have an evisceration Separation of the peritoneum and fascia without separation of the skin, insufficient to allow for egress of abdominal viscera but sufficient to permit escape of the characteristic serosanguinous fluid is a disruption or dehiscence Healing of the skin but failure of healing of the remainder of the abdominal layers when not associated with the passage of pink serum although truly a wound disruption is commonly classed as an incisional hernia

The incidence of wound disruption has variously been reported as 0.22 per cent to 3 6 per cent. The mortality of this complication has been stated by Bowen[5] as 39.5 per cent in a collected series of 1526 wound disruptions and more recently by Wolff[3] as 11 1 per cent. A discussion of the causes of wound disruption encompasses all of the causes of failure or delay in healing, and may be divided into local and general factors.[6]

Local Factors There is evidence that transverse-oblique or muscle-splitting incisions are associated with fewer disruptions[7] Perhaps the most important local factor is the degree of care and delicacy that the surgeon uses Such considerations as hemostasis preservation of blood supply accurate apposition, sterility and prevention of infection minimum of foreign materials and drains, are all important factors under the direct control of the surgeon There is evidence that in addition, the use of nonabsorbable suture materials which cause less tissue reaction than catgut is associated with better healing[8] The problem of catgut sensitivity and allergy and rapid absorption has not been proven. Under local factors it is important to mention that such episodes as abdominal distention hiccough, chronic cough vomiting, and straining

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may be the incident which precipitates the disruption of a wound that is healing poorly and in some instances even a wound that is healing normally

General Factors These are no less important than the local factors although some are not controllable by the surgeon The aged heal more slowly The patient with cardiac or pulmonary disease arteriosclerosis or anemia, does not have a sufficient blood supply to the wound for the processes of healing to proceed at a normal rate Vitamin C because of its effect on collagen formation, vitamin B complex for its necessary enzymatic effects, and vitamin K for its importance in formation of prothrombin, are important to the healing wound. Since the building stones of a wound are protein in nature, it is not surprising that so many authors have emphasized the importance of protein depletion on wound healing. Depleted total blood proteins, blood albumin, and tissue proteins have all been related to the problem of wound disruption [9,10] The author and his colleagues have unpublished experimental evidence to indicate that a stress such as recent surgery severe illness, or trauma, appears to stimulate sufficient endogenous adrenal steroids to interfere with the critical period of wound-healing in animals

Prevention The alert and careful surgeon can prevent a certain number of wound disruptions by first carefully preparing his patient for surgery by correcting protein depletion, anemia, fluid electrolyte and vitamin deficiency The surgeon's second opportunity for preventing wound disruption is during the course of the operative procedure Careful, meticulous technic avoiding mass ligatures preserving blood supply protection of the wound from drying and contamination, adequate hemostasis, careful apposition of all layers of the wound preferably with interrupted fine, nonabsorbable sutures, are all of importance

Postoperatively the surgeon by proper use of a tube and suction, hypnotics and sedatives, can prevent or minimize abdominal distention coughing and straining There is no evidence that early ambulation properly supervised, increases the incidence of wound disruption [2] As a matter of fact the prevention of postoperative pulmonary complications and the easier function of the bladder and colon attributed to early ambulation, probably help in putting less of a strain on the wound.

What more can the surgeon do to prevent wound disruption? When faced with a patient who has poor tissues because of age, chronic illness acute illness with minimal preoperative preparation, malignant disease etc., or when a stormy postoperative course is expected, in addition to the careful layer closure with interrupted fine nonabsorbable sutures we believe that through and through #28 to #32 stainless steel wire retention sutures placed about 2 cm ($^1/_3$ inch) apart should be added to the closure [11] The skin is protected from cutting by the wire by threading 3 cm ($1^1/_3$ inches) segments of #12 or #14F rubber tubing over the wire so that a tied retention suture has a rubber boot between it and the skin. The retention sutures are left in place for a minimum of twelve days, and occasionally as long as twenty-one days. Patients may be discharged from the hospital with the sutures in place These are removed at a subsequent office visit We prefer the through and through suture to the buried figure of eight, or the near and far wire retention suture. The former have less tendency to become untied and the lat

ter particularly in a thin patient, will be a source of postoperative discomfort weeks or months after surgery

Diagnosis and Treatment Having failed to prevent a disruption, the surgeon is faced with the problems of diagnosis and treatment Surgeons who have repaired disruptions have seen evidence that the process has been present for one or more days beneath the skin Most disruptions, although noted seven to ten days postoperatively or when the skin sutures are removed, frequently have their genesis during the critical days of wound healing That is, the three to five days when the wound has not yet begun to pass into the stage of proliferation with a gain in tensile strength. The so-called lag period of wound healing, if prolonged because of failure of wound healing due to any cause will obviously increase the chances of dehiscence because a wound of low tensile strength will be exposed for a longer period to stresses and strains which may disrupt it. When the process of disruption separates the skin suture line either after the removal of sutures or between them there will be an outpouring of a large quantity of serosanguinous serum that usually saturates the dressings and binder This is often the earliest period that wound disruption is diagnosed It is well to institute treatment at this time rather than wait until the intestine has eviscerated Occasionally the catastrophe will first be noted by sudden separation of the skin and simultaneous outpouring of serum and intestinal loops.

Rarely a disruption will occur in the immediate postoperative period, during the course of bronchial suction at the end of the operation, or the excitement stage following recovery from anesthesia. At times the disrupting process is audible to the surgeon the anesthetist, or an attendant.

As soon as practicable following the diagnosis of disruption the patient should be returned to the operating room for resuture The disrupted wound is an ideal site for obstruction of the intestine and the longer repair is delayed, the greater is the chance of obstruction, or the more advanced the process becomes. Since many patients will have disrupted one or more days prior to the diagnosis, intestinal obstruction already will be in effect when the diagnosis is made Indeed this obstruction associated with distention is frequently incriminated as the cause rather than the effect of disruption.

The moment the diagnosis is made, if a gastric or long tube is not already in place it should be passed and attached to suction No attempt should be made to replace eviscerated intestine in the unanesthetized patient. If the skin edges can be opposed without constricting the gut, this should be done with 7.5 cm (3 inches) adhesive strips If one or more loops of intestine are present on the abdominal wall they should be covered with sterile abdominal pads or gauze moistened with sterile saline, and the skin on either side strapped with 7.5 cm. (3 inches) adhesive strips A many-tailed abdominal binder is then placed snugly A sedative such as 0 13 Gm (2 grains) of sodium phenobarbitol is administered The patient is given the appropriate preanesthetic medication and moved to the operating room The choice of anesthesia will depend upon the condition of the patient and the skill and experience of the anesthetist We prefer an anesthesia technic and agent which will give adequate relaxation so that the operative procedure may be

completed with a minimum of handling and as expeditiously as possible Spinal anesthesia, general anesthesia, or regional block expertly administered, will give the desired relaxation Local anesthesia is fraught with the danger of increasing the evisceration if the patient coughs or strains during the course of the operation.

We recommend that the dressings placed to hold the disrupted wound are not molested until the point of adequate relaxation is reached. To remove these supports in an anesthetized patient who is coughing, straining, or in spasm courts the probability of further evisceration With the patient adequately anesthetized, the dressings and supports may be safely removed The eviscerated gut is covered with a moist laparotomy pad and the skin prepared preferably with solutions which will not cause any inflammatory reaction if they come into contact with the serosa. We prefer to wash the skin with pHisoderm and then paint it with aqueous zephiran Any skin sutures that remain are removed, and skin towels applied. The portions of the wound which have not disrupted are then separated by blunt dissection. Any adherent loops of intestine are carefully separated from the wound by blunt finger dissection. Loose suture materials are removed, the intestine replaced in the peritoneal cavity and covered with a moist laparotomy pad.

Many methods of secondary closure have been recommended. We prefer through and through sutures of nonabsorbable material, usually stainless steel wire #28 to #32. No attempt is made at a layer closure In tying the sutures, care must be exercised to guard against catching a loop of intestine between the wire and abdominal wall. The skin between the through and through sutures can be closed with interrupted nonabsorbable sutures

During the postoperative period suction on the gastric tube must be maintained until peristalsis is reestablished and the patient passes gas by rectum Fluid and electrolyte balance and correction of vitamin, blood, and protein depletion is maintained parenterally Antibiotics are usually indicated. Although secondary and tertiary disruptions are rare it is well to keep the retention sutures in place for a minimum of fourteen days Hernia is said to be infrequent following disruption However in our experience and that of others,[3] thirty to fifty per cent of patients will have incisional hernia.

The problem of mortality 11 1[3] to 35[6] per cent is of interest. It does not seem reasonable that the disruption of a wound, even with evisceration of intestine, should be so lethal a consequence. We suggest that the failure to heal the abdominal wound is frequently a manifestation of a generalized process and that the failure of healing of a crucial wound in the gastrointestinal tract with its inevitable peritonitis is responsible for many of the deaths

We do not generally recommend the conservative therapy of disruption We recognize the possibility that in a critically ill patient, a second anesthesia and operation may be lethal For such patients, the passage of a long tube suction, and strapping of the skin may be the only methods of therapy If the gut has eviscerated it may be gently packed into the peritoneal cavity by means of a long petrolatum gauze pack. Patients so treated will certainly have an incisional hernia. The risk of secondary

and tertiary disruption is always present, and most important, intestinal obstruction is an ever present threat. No mortality statistics are available for patients so treated, but obviously they will be high

In conclusion wound disruption is not infrequently preventable if the surgeon will devote more care and utilize the knowledge of surgical physiology of wound healing in the preoperative and postoperative management of his patient and if he follows the dicta of surgical technic so long ago advocated by Halsted Those disruptions that will occur in spite of these safeguards should be treated early and adequately

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The Management of Water and Electrolyte Balance in the Acutely Dehydrated Surgical Patient

THE word dehydration has been used to describe the complex physiologic changes occurring in the body secondary to the loss of one or more constituents of extracellular and/or the intracellular fluid compartments The term is not completely descriptive since it is a generalization that applies to profound and varied physical and chemical changes that occur in body cells and in the fluids that surround them following losses of essential portions of body fluids.

The concepts of the pathology and management of derangements of body physiology produced by acute losses of essential elements of the fluid compartments have been derived from classical and experimental research, the continuance of which has advanced our knowledge of this complex subject. The restoration and maintenance of the water electrolyte protein, and red cell needs of the acutely "dehydrated" patient, however still present many problems. Thus, an awareness of our ignorance of many aspects of body fluid dynamics makes imperative a critical evaluation of the current concepts of fluid therapy

Knowledge of the physiologic reactions leading to acute loss of body fluids is of prime importance, since some conditions produce not only serious loss of salt and water but may be accompanied by important losses of other constituents of the intravascular portion of the extracellular fluid. Acute deficits occurring without associated loss of plasma protein and red cells (*e.g* vomiting diarrhea, biliary pancreatic, or gastrointestinal suction, or fistulous drainage dehydration resulting from high environmental temperature or hyperpyrexia) require a different therapeutic approach than those that do (*e.g* burns, peritonitis intestinal obstruction, gas gangrene, trauma, or *severe infections*) The cation/anion relationship may be seriously affected in certain pathologic states. For instance, loss of chloride in excess of *sodium* which occurs in pyloric obstruction, may produce a disparity of these ions resulting in alkalosis. Conversely the loss of sodium in excess of chloride in the form of pancreatic fistulous drainage may result in acidemia.

A better understanding of acute de

hydration and its resultant physiologic pathology can be obtained from the following considerations (1) Changes in volume of body fluids (2) changes in concentration of the sodium salts and (3) excess or deficit of various ionic or nonionic substances in particular those changes associated with body *pH* with resultant acidemia or alkalemia Potassium disturbances are also included in this group [1]

Changes in Volume Acute water deficit is the simplest form of dehydration Sudden complete cessation of oral water intake is the usual cause of acute water deficit. The deficit of water proceeds more rapidly than the kidney is able to excrete salt to maintain normal solute concentration of body fluids This state is accompanied by acute thirst in the conscious individual. Other clinical signs are oligemia dryness of the mucous membranes elevation of body temperature disorientation progressing to mania and coma (Table 1) The laboratory findings are high urinary specific gravity increased concentration of serum urea proteins sodium and chloride and the sum of chloride plus bicarbonate above 140 *m*-eq

TABLE 1

SIGNS AND SYMPTOMS OF ACUTE WATER DEHYDRATION[1]

Thirst
Weakness
Diminished salivation and lacrimation
Dry sticky mucous membranes
Warm, flushed skin
Elevated body temperature
Tachycardia
Hypotension
Difficult phonation
Hallucinations
Delirium
Coma

Another more complicated form of dehydration involves changes in the volume of the extracellular fluid During health, the volume of the extracellular fluid compartment and the concentration of the solutes are under effective renal control Disease or injury may produce depletion in one or more of the following ways (1) Abnormal extrarenal loss (2) reduced intake of essential elements and (3) loss of effective renal control either through intrinsic kidney disease or extrarenal modification of tubular function

Rapid losses of extracellular fluid may or may not be accompanied by shifts of intracellular fluid into the extracellular space The shift of intracellular fluid tends to serve as a volume buffer to support the vital functions of the extracellular fluid In particular such a shift occurs whenever the concentration of the sodium salts in the extracellular fluid rises above normal with the resultant movement of water out of the cells in response to sodium salt hyperosmolarity The later condition results from loss of water in excess of salt or from the administration of concentrated sodium salts in excess of body requirement. Conversely when sodium salt concentration in the extracellular fluid falls water moves into the cells Under special conditions, this may produce a state in which the cells may be overhydrated while the peripheral circulation is dangerously inadequate because of the sodium salt depletion in the hypo-osmolar extracellular fluid

In the presence of severe sodium salt deficit the total circulating protein diminishes at approximately the same rate as the volumes of plasma and the extracellular fluid [3] The mechanism of this phenomenon is not clear but it is conceivable that the protein catabolized during acute stress is in part, derived from this source

The signs and symptoms of acute loss of extracellular water and sodium salts when such losses proceed at approximately equal rates are principally those of oligemia and the resultant anoxia[4] Subacute losses may produce signs referable to the gastrointestinal tract and to the loss of tissue elasticity The severity of such signs is dependent upon the rapidity of the loss and the resulting quantitative deficit (Tables 2 and 3)

TABLE 2

SIGNS OF ACUTE VOLUME DEFICITS OF EXTRACELLULAR FLUID[3]

Loss, 2 to 4% Body Weight (As E.C.F.)	Loss, 4 to 6% Body Weight
Apathy	Aggravation of all signs of 2 to 4% loss
Weakness	Hypotension
Hypothermia	Retching
Reduced affective responses	Tachycardia
Soft and rapid pulse	Absent venous filling
Orthostatic hypotension	Absent peripheral pulses
Diminished peripheral venous filling	Shock
Syncope	Coma
Cold extremities	

Acute severe deficits are manifested primarily by weakness, apathy diminished peripheral venous filling progressive to absence of venous fill soft compressible pulse tachycardia, falling blood pressure that may progress to shock levels and coma, cold extremities, and lowered body temperature Laboratory signs may be of little value Chloride is usually absent in the urine if good renal function is present. Casts, albumin, and red blood cells may be present in the urine in severe deficits Red blood cell counts, hemoglobin concentration, the hematocrit reading and level of urea may be elevated.[1]

Changes in Concentration of Sodium Salts. The sodium salts and water of the extracellular fluid in health, are

TABLE 3

SUBACUTE SIGNS OF EXTRACELLULAR FLUID DEFICIT[3]

(These may include any and all of the symptoms of acute deficit)

Loss, 2 to 4% Body Weight	Loss, 4 to 6% Body Weight
Anorexia	Aggravation of all signs of 2 to 4% loss
Nausea and vomiting	Wrinkling and longitudinal furrowing of tongue
Diminished thirst	Marked loss of tissue turgor
Ileus	Soft and sunken eyeballs
Beginning loss of tissue turgor	Putty-like muscles

maintained at a remarkably constant ratio by the normal kidney (155 m-eq base per 1000 ml. of water of which ninety per cent is sodium salts) The healthy kidney jealously guards this relationship Pathologic states that interfere with renal function or produce a disparity in the rate of loss of sodium salts and water may result in a relative or absolute increase (hyperosmolarity) or decrease (hypo-osmolarity) in sodium salt concentration These are particularly prone to occur in acute severe deficits before effective renal fuction can compensate by excretion of excess base or water

Relative or absolute water excess with associated severe sodium salt depletion may produce progressive oliguria Under these circumstances adequate renal excretion can be restored only by the correction of the extracellular fluid to proper osmolar concentration. Attempts to increase urinary output by the administration of water alone may result in anuria and fatal water intoxication

Laboratory determination of serum bicarbonate and chloride may be of value in estimating the degree of hypo- or hyperosmolarity[5] The normal sum

of chloride (103 m-eq) and bicarbonate (27 m-eq) is 130 m-eq In the absence of acetonuria or increased blood urea a sum of serum bicarbonate plus chloride below 120 m-eq presumes hypo-osmolarity of the serum solutes Conversely a sum of these two ions above 140 m-eq suggests hyperosmolarity of the sodium salts

In contradistinction to increased sodium salt concentration in the extracellular water certain pathologic states may produce an absolute or relative diminished salt concentration with associated water excess This condition may attain when uncompensated sodium salt loss continues while unlimited access to water is permitted (as in severe sweating fistulous gastrointestinal tract drainage salt losing nephritis etc) or overadministration of water when renal function may be severely depressed (as in postoperative or posttraumatic oliguria)

The pathologic physiology associated with sodium salt hypo-osmolarity for the most part is related to cellular overhydration rather than to extracellular volume deficit because water moves into the cell from the extravascular spaces in response to this hypo-osmolarity Symptoms of water intoxication may thus be produced The volume of extracellular fluid however may be reduced normal or increased depending upon the degree of overhydration A paradox of cellular overhydration with associated peripheral circulatory collapse is therefore possible in this condition provided that sodium salt depletion is severe enough to reduce effectively the volume of the blood plasma

Clinical signs of water intoxication (sodium salt hypo-osmolarity) are related to overhydration of the central nervous system and the extrarenal excretion of water (Table 4) Of importance are elevated cerebrospinal fluid pressure hypertension, brachycardia, projective vomiting muscle twitching, convulsions heat (Stoker s) cramps, salivation and diarrhea Laboratory findings are oliguria progressing to anuria, low urinary specific gravity absence of urine chloride and the sum of serum bicarbonate and chloride less than 120 m-eq Blood chloride may be low

Changes in Ion Composition of Body Fluids: The defense of body fluid *p*H is accomplished by respiratory control of the carbonic acid (H_2CO_3) of the blood and the renal control of the ionic concentration of the serum [6] Illness or injury producing acute loss of extracellular fluid may also cause an unequal loss of cation (sodium) as compared to loss of anion (bicarbonate and chloride) Up to a certain point this inequality will be compensated for by the renal excretion of the ion in excess The hydrogen ion concentration cannot be defended indefinitely in this manner however as progressive extracellular fluid loss precludes further salt excretion Serum volume will be defended by the kidney in preference to serum *p*H with subsequent production of acidemia or alkalemia

Ionic imbalance produced by acute dehydration will be in almost all cases the result of losses of the specific ions The ionic composition of the type of fluid lost primarily determines whether alkalemia or acidemia will result. Pyloric obstruction for example produces a loss of both sodium and chloride ions but the loss of chloride is in excess of sodium because of the nature of the gastric juice As a result, bicarbonate ion is substituted for the lost chloride ion and alkalemia results Drainage

TABLE 4

SYMPTOMS OF SODIUM SALT HYPO-OSMOLARITY (WATER INTOXICATION)[1]

- Headache
- Muscle (Stoker's) cramps
- Disturbances of vision
- Elevated cerebral spinal fluid pressure
- Nausea and vomiting
- Brachycardia and hypertension
- Papilledema
- Muscle twitchings
- Convulsions
- Lacrimation
- Salivation
- Intracutaneous edema

from a pancreatic fistula, on the other hand produces a loss of sodium in excess of chloride The resultant ionic imbalance from excessive loss of $NaHCO_3$ produces acidemia.

The medullary centers controlling respiration are quite sensitive to changes of *p*H of the blood In an attempt to compensate for an increase or decrease in the base bicarbonate ($BHCO_3$) resulting from ionic imbalance the carbonic acid (H_2CO_3) content of the blood may be increased or decreased by modifying the rate and amplitude of respiration Acidemia with associated lowered base bicarbonate ($BHCO_3$) produces increase in rate and amplitude of respiration which lowers blood carbonic acid (H_2CO_3) by blowing off CO_2 As a normal ratio between $H_2CO_3/BHCO_3$ is approached, signs of increased respiratory activity diminish. Laboratory examination of the blood may reveal a sharply reduced CO_2 content while *p*H determination may be within normal limits [4]

Alkalemia may produce a diminished amplitude and slowing of respiration in an attempt to retain CO_2 and increase the H_2CO_3 content of the blood to compensate for the absolute or relative increase of $BHCO_3$ During a compensated phase, blood *p*H may be normal even though the CO_2 content is greatly increased Tetany may also be produced by alkalemia resulting from rapid and severe loss of extracellular fluid in which chloride is lost in excess of sodium

Compensated acidemia and alkalemia produce few if any clinical signs in the resting patient. *Thoughtful, circumspect* consideration should always be given to the chemical determination of the CO_2 content of the blood since it tells little about the relationship of $H_2CO_3/BHCO_3$ or the blood *p*H A careful review of the mechanism producing the ionic disparity as astute evaluation of the attending physical signs and a blood *p*H determination are of equal value in the diagnosis and treatment of such ionic imbalances.

Potassium Deficit Potassium is the chief intracellular base The loss of potassium from the cells and the attendant loss of water should thus be considered a volume change. The clinical manifestations of potassium deficit, however may be observed before serious intracellular dehydration has occurred. Many aspects of the abnormal physiology of potassium remain poorly understood, but enough has been learned about serious potassium deficits in surgical patients to insure rational treatment.[7]

Significant potassium loss may be anticipated in the following surgical conditions Pyloric obstruction prolonged

TABLE 5

SYMPTOMS OF POTASSIUM DEFICIT[8]

- Weakness which may progress to flaccid paralysis of the muscles
- Anorexia and vomiting
- Disorientation
- Ileus
- Soft, pliable muscles
- Acidemia or alkalemia refractory to sodium bicarbonate or sodium chloride therapy

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maintenance on parenteral fluids particularly when sodium salts are given without potassium rapidly growing neoplasms severe alkalemia and acidemia ulcerative colitis chronic manition and fistulous drainage or suction from the gastrointestinal tract. The clinical manifestations of potassium deficit, however often may be masked by deficits of extracellular fluid and present themselves only when this loss is corrected [8]

Signs and symptoms of potassium deficit may include weakness with associated hyperactive reflexes and fascicular twitchings which may progress to flaccid paralysis of the muscles anorexia vomiting disorientation progressing to coma ileus, soft pliable muscles alkalemia and acidemia refractory to specific corrective measures (Table 5) Laboratory signs are electrocardiograph findings of low voltage flattening of T waves and the S-T segment, low potassium concentration in the serum in the presence of adequate urinary output.

Treatment All attempts to replace constituents of the extracellular and intracellular fluid compartments lost by mechanisms producing acute deficits must be geared to the history and the clinical picture of the patient. There is no such entity as the "typical" fluid balance problem Effective rules and formulae universally applicable for the re

TABLE 6

FLUID REPLACEMENT OF ACUTE EXTRACELLULAR LOSS

Component	*Type of Fluid*	*Amount*	*Rationale*
Shock	2% NaCl	500-1000 cc.	Hypertonic saline rapidly expands the extracellular fluid volume by drawing water out of the cells and into the extracellular spaces. Rate of administration should not exceed 500 cc. per hour
	Whole blood	Various with need. Minimum 500 cc.	Rapid expansion of the intravascular portion of the extracellular fluid. Bolsters the oxygen and CO_2 carrying power of effective circulating intravascular fluid.
Volume deficit (no osmolar or ionic imbalance)	Riner lactate (Hartmann's solution)	2-6% of BW as initial replacement load depending upon clinical signs (Table 1)	Replacement of extracellular fluid deficit with fluid of approximately the same ionic composition. Rate of administration varies with need and status of cardiovascular system.
	5% glucose in distilled water	Varies with environmental temperatures and fever but a minimum of 1500-2500 cc. is initially necessary	To cover insensible loss from the skin and lungs and to provide water for urine formation. Removal of water from concentrated salt solutions may be inefficiently performed by the kidney under circumstances of such acute deficits.
	Whole blood	Need various but usually about 500 cc. per 3000 cc. of repair fluid.	Supplies plasma protein to cover acute protein loss of large sodium salt deficits. Augments oxygen and CO_2 carrying power of intravascular fluid.
Hyperosmolarity (Increased sodium salt concentration)	5% glucose in distilled water	Administered until normal osmolarity is restored.	Dilutional effect of water without salt restores iso-osmolarity Severe hyperosmolarity should be corrected before concomitant fluid deficits are Less severe hyperconcentrations may be treated simultaneously with volume deficit.

TABLE 6 (Cont d.)

Component	*Type of Fluid*	*Amount*	*Rationale*
Hypo-osmolarity (Decreased sodium salt concentration with water excess)	2% NaCl	Administered until iso-osmolarity is restored.	Restores normal ratio of plasma water and NaCl by providing salt in excess of normal concentration. Overexpansion of the extracellular fluid volume must be watched for particularly in elderly individuals.
Acidemia	M/6 Sodium lactate	Variable usually 250-500 cc.	Lactate radical rapidly metabolized by liver leaving sodium available for augmenting $BHCO_3$.
	1.3% $NaHCO_3$	Variable, usually 250-500 cc.	Used in shock or in poor liver function as sodium lactate becomes ineffective in these conditions. Severe acidemia or alkalemia necessitated early and intensive treatment.
Alkalemia	Isotonic NaCl	Variable usually 1000-2000 cc.	Acts as an "acid" salt in alkalemia by providing chloride ions in excess of requirements of serum.
	0.9% NH_4CL	Variable; usually 1000-2000 cc.	Rarely necessary in severe alkalemia, provides a marked excess of chloride ions to combat HCO_3 excess (metabolic alkalemia)
Hypopotassemia	2-4% KCL in 5% glucose or Ringer's solution	4-6 Gm. KCL per day for maintenance 6-12 Gm. —per day for repletion.	Restores chief intracellular electrolyte thus preventing or correcting intracellular dehydration and abnormal serum levels.
Serious red blood cell and plasma protein loss	Whole blood	Variable and depends upon the mechanism producing deficit; serious trauma (e.g., burn) may necessitate as much as 3000-4000 cc. the first 24 hours.	Replacement of red blood cells and plasma proteins lost externally or made physiologically ineffective by sequestration into injured or inflamed area. (Distributional shift.)
	Plasma	Variable	Should be used when whole blood is unavailable or under circumstances of minimal red blood cell loss with associated severe plasma protein deficit. Sodium salt and water losses associated with such deficits should be treated as extracellular fluid volume deficits.

placement of electrolyte and water cannot be offered because of the necessity of adjusting such administration to the clinical condition of each patient. Too much emphasis cannot be placed upon the importance of using the clinical status as the primary guide to therapy Laboratory studies of the blood and urine may provide important confirmatory evidence, but reliance upon them as an absolute guide is inaccurate and may be hazardous Most effective treatment is obtained as a result of the careful correlation of all clinical and laboratory guides with the clinical status paramount in the estimate of the situation.

Severe disturbances in osmolar and ionic composition of extracellular fluid should receive early and intensive therapy Their correction except in the presence of shock has preference over correction of volume deficits Less serious osmolar and ionic defects may be simultaneously treated with volume deficits

Table 6 presents an outline of the treatment of the principal components of acute dehydration Acute deficits of extracellular fluid that have produced shock (blood pressure less than 70 mm Hg) should be treated vigorously with hypertonic saline and whole blood in addition to routine antishock measures A two per cent solution of sodium chloride has been found effective for this purpose The administration of hypertonic saline should not be carried out at too rapid a rate as it may produce unpleasant side reactions. Administration in excess of 300 to 500 ml. per hour should be accomplished with great caution

Deficits without shock or significant osmolar or ionic change can be treated with Hartmann's solution (Ringer solution, 950 ml., with 50 ml ⅙ molar sodium lactate) the amount given depending upon the clinical signs of the deficit (Table 2) A deficit estimated at six per cent of body weight in a 70 kg man require 4200 ml. (0 06 x 70 x 1000 = 4200) Allowance must also be made for obligatory fluid expenditures, insensible and respiratory losses. Insensible loss through lungs and skin varies greatly with the environmental temperatures and degree of hyperpyrexia. Under these circumstances a minimum of 1500 ml of five per cent glucose in water should be given to cover this need in the adult patient Another 1000 ml of five per cent glucose in distilled water should be administered to provide water for urine formation In all acute sodium salt deficits whole blood should be administered to cover the attendant immobilization or loss of plasma proteins (Table 6)

During a period of repletion and maintenance of a seriously dehydrated patient, several liters of electrolyte and glucose solutions together with blood and plasma must be given There are hazards of overhydration particularly in elderly patients those with poor cardiac reserve or those with temporarily depressed renal function Symptoms of overhydration must be watched for and the administration of the fluids slowed down or discontinued as may be necessary

Potassium salts, if indicated should be added to repair solutions after adequate urinary excretion has been established (700 to 1000 ml per twenty four hours) The oliguria associated with large losses of body fluids may make the immediate administration of potassium salts hazardous because of the danger of producing heart block when serum potassium levels approach 10-12 m-eq (Table 6)

Acute deficits of extracellular fluid produced by severe trauma or inflammation are for the most part, accompanied by serious losses of plasma protein and red blood cells as well as sodium salts and water (*e g* burns peritonitis intestinal obstruction gas gangrene fractures, and severe crushing injuries) In addition to possible external loss of fluid, there occurs a distributional shift of fluids from the effectively functioning extracellular fluid into the inflamed or traumatized part of the body This sequestered extracellular fluid is ineffectual in supporting the vital functions of the remaining intravascular and interstitial fluid and if the shift is sufficiently

large, serious signs and symptoms of extracellular fluid deficit may appear in the uninjured part of the body [1] Principles of volume deficit therapy are applicable to the support of the effective extracellular fluid during the acute phase of this type of injury

The proper management of acute deficits associated with serious loss of plasma protein and red blood cells will require adequate transfusion of whole blood and plasma as well as sodium salts and water if a maximal therapeutic result is to be obtained.

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Prevention and Treatment of Post-Transfusion Reactions

UNTOWARD post-transfusion reactions are obviously undesirable yet it is impossible to carry out a large series of transfusions without experiencing these complications It is incumbent upon us, however to reduce their incidence to a minimum At one time reactions by the citrate method of transfusion ranged as high as fifty per cent, whereas now it is possible to keep them at approximately one per cent. A survey of a group of large hospitals doing thousands of transfusions showed that the average incidence was approximately five per cent. If the incidence is higher than that, a thorough study of the situation should be made to determine the cause so that corrective measures can be undertaken. It must be remembered that reactions tend to occur in flocks There will be periods when there are no or almost no reactions followed by periods during which the incidence is relatively high Therefore in determining the efficacy of any transfusion department statistics must be viewed on an annual basis rather than only during a period when something has quite evidently gone wrong. By the same token, if the examination is made during a period when no reactions occurred, this does not mean that the overall incidence of reactions in that particular institution is nil.

Post-transfusion reactions can be divided into three groups 1 Allergic, 2 pyrogenic, 3 hemolytic.

(1) Allergic reactions are due to intravenous injection of material to which the recipient is sensitized. One of the most severe allergic reactions I have observed was in a physician's wife who after the transfusion stated that she was allergic to eggs Upon investigation, it was found that the professional donor whose blood she had received made it a habit to eat eight eggs a day with the idea that this would help him maintain the hemoglobin concentration of his blood at a high level and enable him to donate blood more frequently A similar allergic reaction occurred in a patient who was sensitive to fish It was found on investigation, that the donor had eaten two meals of fish on the day prior to his donation of blood In some cases, in which an allergic reaction has occurred, it is difficult to ascribe it to anything except perhaps the plasma proteins of the donor's blood. In such patients a reaction may follow every transfusion. In most instances this reaction can be eliminated by giving washed erythrocytes rather than

whole blood These washed erythrocytes may be resuspended in normal saline or given in concentrated form

An allergic reaction is generally evidenced by the appearance of urticarial wheals These may be few in number and then are apt to appear on exposed parts of the body as the face, neck, and arms. The commonest site is the eyelids or lips. However the number of wheals may be innumerable They may be small or extremely large and then even become confluent so that the skin may take on a pigskin appearance They may involve the bronchial mucous membrane and produce coughing Although an allergic reaction may be very severe and distressing in my experience of very many hundreds of thousands of transfusions I have seen only a single case which was fatal. The wheals were giant in size and became confluent, pulmonary edema developed, and death resulted

The treatment for an allergic reaction is adrenalin chloride 0 3 to 0 6 cc (5 to 10 minims) subcutaneously This should be repeated if necessary Small gauze squares immersed in ice water should be placed on the eyes or the lips if they are involved. For the skin elsewhere, a one per cent solution of menthol in alcohol should be applied to the urticarial wheals.

(2) Pyrogenic reactions are caused by introduction of pyrogens into the blood stream and these pyrogens, as the name indicates are substances which produce fire or heat. They are products of bacterial growth. Certain of their properties are known. They are relatively thermostable, inasmuch as they cannot be destroyed by autoclaving They can be destroyed at extremely high temperatures but then this would destroy the other materials which are being sterilized, and therefore this is of no practical value. They cannot be removed by passage through any filter even those that remove bacteria, except by adsorption when a fluid containing pyrogens is passed through a Seitz filter using a serum #3 pad. Bacteriological examination of a fluid may show that it is sterile and yet it may be pyrogenic. The presence of pyrogens in a fluid can, however be determined by the reaction of rabbits to intravenous injection of this fluid. The high incidence of post-transfusion reactions in the early days of citrate transfusion was undoubtedly due to pyrogens. With the understanding of the nature of pyrogens, methods for their elimination were developed. The foundation stones on which these rest are the use of pyrogen-free distilled water in the cleansing of equipment and meticulous care to see that after they are removed they are not reintroduced or permitted to redevelop To allow clean, moist, pyrogen-free though nonsterile apparatus to remain unsterile favors development of pyrogens. Such apparatus must be sterilized at once before there is time for pyrogenic bacteria to grow While it is possible for pyrogen-free equipment to be prepared in the average institution, it is difficult. If undertaken, one must be certain the water-still is adequate to produce pyrogen-free distilled water Commercial houses have developed to a high degree the technic for elimination of pyrogens so that now expendable, sterile, pyrogen-free equipment is available to all This is largely responsible for the great reduction in the incidence of pyrogenic reactions Yet even with such commercial equipment, pyrogenic reactions still occur

The symptoms of a pyrogenic reaction are elevation of temperature with or without a chill. Headache, nausea,

vomiting, may also appear. The temperature rise varies from 1° F. upward. The highest I have observed was 109° F. (42.8° C.). The rise in temperature may appear almost immediately or may be delayed and appear within the first few hours after the transfusion. When blood has been administered more or less simultaneously with the performance of a surgical operation and fever develops, it is impossible in most instances to differentiate between a posttransfusion and a postoperative rise in temperature. Physicians, for whom transfusions are carried out, must recognize that in the present state of our knowledge, it is hardly feasible to do this work without experiencing occasional reactions. Furthermore every rise in temperature following a blood transfusion is not of necessity due to the transfusion. The treatment for a pyrogenic reaction is aspirin 0.6 Gm. (10 grains) followed by 0.3 Gm. (5 grains) four times a day for two or three days. Generally the temperature drops by crisis or at other times by lysis over a period of twenty-four hours or more.

(3) Hemolytic Reactions. Hemolytic reactions, as the name indicates, are due to hemolysis. Most of these reactions are avoidable since they are often the result of lack of knowledge or human error. Almost always, the donor's red cells are hemolyzed by antibodies present in the patient's plasma and which are specific for an antigen present in the donor's red blood cells. The reverse is possible especially if the patient has had a massive hemorrhage or in children where, relatively speaking, the amount of transfused blood is great in comparison to the child's blood volume and particularly if the child has had a hemorrhage. Antibodies present in the patient's plasma and specific for the donor's cells act on them readily because the patient's blood volume is many times that of the transfused blood and the large volume of the patient's plasma, therefore, contains sufficient amount of antibodies quickly to act on the relatively small number of transfused cells. The reverse rarely happens because donor's blood, if it does contain antibodies specific for the patient's cells, is diluted many times by the patient's plasma, thereby producing a very low concentration of these antibodies which can readily be absorbed by the large volume of the patient's cells. This is the basis for using group O donor as a so-called universal donor. Yet even then, using a group O donor for a patient of another blood group is not always without danger not only for the reason previously mentioned but also antibodies by attaching themselves to the patient's cells may produce a condition not unlike an acquired hemolytic anemia. When a "universal" donor is used, therefore, only group O blood having a low titer of anti-A and anti-B should be transfused. Otherwise the supernatant plasma should be removed in order to avoid introducing antibodies contained in it. The addition of group A and B substances has been used to reduce the antibody titer but this may be undesirable in a female prior to the end of her child-bearing period and theoretically could be responsible for erythroblastosis fetalis in her newborn infant.

With the simplification of technic for transfusion the procedure became more common and as early as 1921 Unger[15] noticed that occasionally when carrying out pretransfusion cross-matching tests small clumps of cells were present even though the blood of both donor and patient belonged to the same A-B-O group. He also reported that transfusion of such

blood resulted in chill and fever which he considered a hemolytic reaction He theorized that the A B-C group of an individual was established by a "chief" or "major" agglutinin and that the observed intragroup incompatibility and the post-transfusion reaction was due to a "para" or "minor" agglutinin. This so-called "minor" agglutinin was undoubtedly the first report of what is now known as the Rh_0 blocking antibody and the antigen for which it was specific, the Rh_0 factor because Unger's cross-matching tests were routinely carried out using the patient's plasma and the donor's plasma, respectively for the suspension of their cells whereas others at that time used saline The Rh_0 blocking antibody we now know clumps specific cells only when suspended in high colloid media and fails to clump in the presence of saline

With the development of blood banks the number of transfusions administered increased and as result, intragroup incompatibilities also increased in frequency and a series of such cases were studied and reported by Culbertson and Radcliffe, Pondman, Zacho Meter Mosonyi Levine and Stetson. In 1937 Landsteiner and Wiener injected rhesus blood into rabbits which developed antibodies specific for an antigen present in the blood of approximately eighty five per cent of Caucasoids. This antibody bore no relationship to the A, B M N and P factors They named the new factor which they discovered, the Rh factor In 1939 Wiener and Peters studied cases of post transfusion hemolytic reactions and found that the blood of each patient lacked the Rh factor although it was present in the blood of each donor used for these transfusions They also found that the patient's serum contained antibodies that clumped the cells of approximately eighty five per cent of Caucasoids and acted independently of the A B-O M N and P factors and they concluded that the blood factor involved in these hemolytic reactions was the Rh factor Wiener[3] also stated that "in retrospect, it therefore seems reasonable to conclude that the majority of the earlier irregular agglutinins found in the sera of patients sustaining intragroup hemolytic reactions were also rhesus"

As a result of these various studies it is now recognized that Rh-positive blood transfused to an Rh-negative patient may produce Rh sensitization It was also shown by Levine et al that sensitization may develop in an Rh-negative woman pregnant with an Rh-positive fetus if the erythrocytes of the fetus pass through the placenta into the maternal circulation.

Although the problem of hemolytic reactions became more troublesome in recent years, simultaneously there has been a great increase in our knowledge and understanding of the subject. The reason why the danger has increased is that never before have so many patients been transfused and never before have individual patients received as many transfusions I saw in consultation an Rh-negative male patient with intestinal hemorrhage. He had been given 121 transfusions totaling 62,500 cc. of blood over a period of seven weeks The first thirteen were transfusions of Rh-negative blood The last 108 were Rh-positive and these were all given within a period of nine days. This case teaches several lessons Firstly Rh-negative patients should only receive Rh-negative blood and Rh-positive patients Rh-positive blood Yet, necessity may compel deviation from this rule This was a case in point. One must weigh the danger of sensitizing a patient

by the Rh factor against the danger of withholding transfusion Once sensitization develops Rh positive blood must no longer be administered. Furthermore if the patient is female one must keep in mind the danger of erythroblastosis fetalis at the time of a future pregnancy A second point which this case illustrates is that huge amounts of citrated blood given almost continuously may not control hemorrhage and may even increase it In this case at first no calcium gluconate had been given and it was only after the practice of giving intravenously 10 cc. of ten per cent calcium gluconate after each 1000 cc of blood was hemorrhage controlled In patients requiring massive transfusion of citrated blood, this practice should be routine A third fact that this case illustrates is that multiple transfusion of the same individual may lead to development of antibodies which would never appear if as in the past only a single transfusion of one or possibly two pints of blood were given Although two or three transfusions given at wide intervals are more apt to sensitize an individual than multiple transfusions given in a short space of time this patient did develop Rh_0 antibodies It was also surprising that although he was exposed to very many antigens yet he responded to only one

With sufficient stimulation, a certain number of recipients will become sensitized to one or more hemagglutinogens lacking from their blood cells There are many different hemagglutinogens and their antigenicity varies The ability to respond to antigens also varies with the individual Some individuals are more responsive to antigenic stimulation than others The most susceptible may respond to the poorly antigenic factors Some highly susceptible individuals even produce autoantibodies which attack their own red blood cells, for example patients with acquired hemolytic anemia whose blood shows the presence of autoantibodies are most apt to be sensitized in addition by the least antigenic blood factors In fact, such patients may develop multiple sensitization to several different blood factors so that it becomes extremely difficult to find a compatible donor If after a transfusion a hemolytic reaction occurs a thorough hematologic examination must be made to determine the cause In the interim further transfusions should be withheld. At this point, it is wise to remember that transfusion is not without danger and should only be used when there is definite indication

From a practical point of view it is impossible to give every patient transfusions of blood not containing any blood factor lacking from the recipient's blood cells Although not too long ago only a single blood system was known and tested for namely the A B-O now we know of at least nine different blood group systems each containing a series of different antigens which together determine more than 50 000 varieties of blood Thus, the complete blood grouping of an individual is becoming almost as distinctive as his thumb print. It is utterly impossible for any Blood Bank to maintain that number of varieties of blood available at all times Fortunately this is not essential, and for practical purposes it is sufficient to confine the work to the two most important blood group systems, the A B-O and the Rh-Hr Yet when most of the varieties of these two systems are taken into account, there are still seventy two different varieties of blood Since in the Rh Hr system all factors except Rh_0 are but weakly antigenic the accepted prac

tice today in Blood Banks is to limit the variety of bloods to eight namely Rh_0 positive and an Rh_0-negative variety of each of four A B-O Groups In problem cases however one must be prepared to go beyond this

In order to take every reasonable precaution to avoid a hemolytic reaction certain tests are incorporated in the cross-matching procedure which should be carried out prior to every blood transfusion, except in emergencies Detailed description of the technic of these tests has no place here, and for this information the reader is referred to the literature. Suffice it to say here that there are two forms of an antibody of a given specificity which may cause a hemolytic reaction. They are called the bivalent (agglutinins) or univalent (glutinins) form of the antibody For any cross-matching technic to be adequate, it must detect both these forms The bivalent form can be detected when saline medium is used. The univalent form can be detected only by using colloid media or by special technic using the antiglobulin test (Coombs) or enzyme-tested cell method. The Duffy and certain other antibodies which can cause a hemolytic reaction can only be detected by the antiglobulin test so that this test should be done routinely but most particularly in cases where the recipient has received previous transfusions

The symptoms of a hemolytic reaction may appear almost immediately in fact, after only as little as 50 cc of blood have been transfused, or they may not appear until late in the transfusion or at times until sometime after it has been completed The possibility of hemolysis should be thought of whenever the recipient complains of pain in the small of the back followed by pain radiating down the back of the thigh during a transfusion Usually these symptoms appear early and are an indication for immediate discontinuation of the transfusion These early symptoms may be followed by chill rise in temperature tachycardia dyspnea cyanosis nausea, vomiting, and even pulmonary edema and death. Some patients may soon completely recover from the initial symptoms while others may later develop hemoglobinuria, oliguria anuria, and hemolytic icterus

Besides interruption of the transfusion at the earliest appearance of symptoms the patient should be given 1000 cc of ⅙ molar sodium lactate intravenously and 0.3 Gm (5 grains) of sodium bicarbonate by mouth every two hours for three doses For the more serious cases, 15 mg (¼ grain) of morphine sulfate, 0 6 mg (1/100 grain) of atropine sulfate and 0 6 cc. (10 minims) of adrenalin chloride are given subcutaneously by hypodermic injection These drugs should be repeated, if necessary giving progressively smaller doses alternating each every fifteen minutes

Exchange transfusion should also be carried out in severe cases where a large amount of incompatible blood has been given About five years ago I carried out the first such exchange transfusion. Two patients one group A and the other group B had been properly cross-matched with compatible blood. Yet, the nurse on the ward, by error reversed the bottles and 500 cc group B were given the group A patient, and 500 cc. of group A blood were given the group B patient. When the error was discovered, oxalated specimens of blood were taken from both patients, then centrifuged and the supernatant plasma of each was compared with the supernatant plasma of the respective pretransfusion

specimens which had been drawn for the purpose of cross-matching Examination of these showed that no hemolysis had occurred in the group A patient to whom B blood had been erroneously given. Therefore nothing whatsoever was done to this patient and she made a complete and uneventful recovery Titration of the serum of this patient's pretransfusion specimen showed an extremely low titer of anti-B This was fortunate and accounts for lack of evidence of hemolysis However there was evidence of marked hemolysis in the group B patient who had received group A blood. An exchange transfusion was undertaken Five hundred cc. of blood were removed and then replaced. This was continued until 5000 cc had been both removed and replaced The next day there was some icterus of the patient's conjunctiva and skin but she went on to an otherwise uneventful recovery Examination of the blood removed at the end of the exchange transfusion showed a marked reduction in the icterus index as compared with that of the specimen taken at the beginning of the procedure

If the patient survives the initial symptoms, the urinary output should be measured a sample of each urination should be put in a test tube labeled with the date and hour it was passed. These test tubes should be racked so that they can be compared Each specimen should be tested for its acidity and the treatment directed toward maintenance of alkalinity so that the hemoglobin of the hemolyzed red cells can be excreted in solution in the urine rather than precipitated as acid hematin crystals in the tubules of the kidney

A hemolytic reaction may be so mild that clinically it is difficult to distinguish from a pyrogenic reaction For this reason, if a post transfusion reaction occurs no further blood should be administered until proper tests have been made to differentiate between a pyrogenic and a hemolytic reaction. The simplest and quickest test is to obtain an oxalated specimen of blood after the reaction has subsided and to centrifuge this as well as the specimen of blood used for preliminary cross matching test, and compare the supernatant plasma of each If the plasma of the post transfusion specimen is darker or definitely more reddish than the pretransfusion specimen, the reaction is to be construed as hemolytic in nature Careful and intricate tests must then be carried out to determine whether antibodies capable of causing the reaction are present and if so their specificity should be established If then further transfusions are required, only blood should be used which lacks the antigen for which the patient's plasma contains specific antibodies To obtain this information, it is necessary to test for the A, A_1 B Rh_0, rh rh" hr' hr" M N S K-k Kidd and Duffy factors It may be necessary to go even further than this and test for rarer antibodies

If for any reason it is impossible to carry out such blood tests and the patient urgently requires additional blood one is justified in resorting to the "biological test." This consists of transfusing 50 cc of the donor's blood and waiting two hours If no reaction occurs within that period this donor's blood is presumably compatible This should however be further verified by examining the recipient's plasma for evidence of hemolysis If the result is negative the balance of the blood tested may be administered If hemolysis or a chill does

occur within the two hour period the blood is presumed to be incompatible and no more of this particular donor's blood should be administered A full 500 cc. (1 pint) of such blood might cause death, but 50 cc. will not.

Although truly not post transfusion "reactions," there are post-transfusion complications which merit inclusion at this point. They are the development of syphilis malaria or homologous serum jaundice in transfused patients Post transfusion syphilis rarely occurs today because ample time is available carefully to test the donor's blood and eliminate that which is syphilitic. In addition, if the blood has aged in the ice box for three days transmission of syphilis by transfusion is considered impossible Malaria and homologous serum jaundice are however different matters They must be considered "calculated" risks associated with transfusion. Unfortunately there are no practicable tests which can be carried out to eliminate donors capable of transmitting these diseases and thereby avoid these risks. I have carried out tests for malaria using the thick smear technic on 20 000 consecutive donors without success. The most that can be done is to obtain a very careful history from the donor and to refuse to utilize the blood of any donor who has *ever* had either nonobstructive jaundice or malaria, or who has received malarial suppressive treatment within a year of the date of donation. The problem of malaria increased in importance with World War II when men returned from duty in areas where malaria was endemic and became blood donors Recognizing that a carrier of the virus of homologous serum jaundice may have had no visible jaundice all donors should also be asked whether they have ever had an undiagnosed illness with a prolonged period of unexplained fever If so they should be categorically rejected

Other complications may occur due to the route used for the introduction of blood While the usual route is a superficial vein and using such is almost always innocuous at times phlebitis may develop When blood is transfused into the peritoneal cavity the medulla of a bone the superior longitudinal sinus or the umbilical vein, there are special problems and complications associated with each The first two routes mentioned are now almost entirely abandoned and actually should never be used. With the intraperitoneal route there is danger of injuring an abdominal organ and when the medulla of a bone is used, there is the ever present danger of osteomyelitis developing One should always remember that when a blood transfusion is indicated, the blood should be given directly into the circulation. Although the superior longitudinal sinus is useful in infants, it should only be undertaken by a specialist, since care must be taken not to inject blood subdurally and for this experience is needed. The umbilical vein is used for newborn infants particularly for replacement transfusion if erythroblastosis fetalis exists This route too carries with it dangers such as air embolism or thrombosis and should be used only by specialists in this field.

With the advent of blood banks, the danger of blood contaminated by bacteria was introduced. When direct transfusions were given or when citrated blood was drawn and administered immediately even though some bacterial contamination may have occurred, only relatively few organisms were intro-

duced, and the patient s body mechanisms were able to destroy these When on the other hand, blood, which has been contaminated is stored in a bank, the problem is different and more seri ous Blood is a good culture medium With storage, especially if at some point the blood is not continuously maintained at a temperature of 2 to 4 C. bac teria may multiply It has also been shown that certain bacteria may multiply at ice box temperature Under either circumstance transfusion of such bac terially contaminated blood may be followed by fever chill possibly phlebitis and even death. There is no known practicable way to determine the pres ence of bacteria in banked blood, but daily inspection helps The presence of hemolysis in the supernatant plasma should arouse suspicion and such blood should be discarded. An additional procedure is to compare the supernatant plasma of the bottle of blood with that of the pilot tube If the former is cloudy and the latter clear the blood should be discarded Culturing blood is useless because the very procedure may contaminate a previously sterile bottle, and furthermore, the blood will become out dated before the results of the culture are obtained Using only sterile mate rials and aseptic precautions in the collection of the bottle of blood is the best and only protection Every Blood Bank voluntarily should adhere, at least, to the minimum standards of the National Institutes of Health United States Public Health Service, even though it may not be licensed by that agency

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Emergencies in the Course of Anesthesia

EMERGENCIES may arise in the course of anesthesia for any operation. In some instances the nature of the emergent condition can be anticipated because of the precarious physical state of the patient, or because of the type of operation which the surgeon proposes to do or something unforeseen may occur in the course of administration of an anesthetic to a seemingly healthy patient who is undergoing an uncomplicated operation. Emergencies encountered by physicians in other fields of practice frequently can await treatment while all available facilities for diagnosis have been utilized over a period of many minutes or even hours. Anesthetic emergencies often require extremely prompt recognition diagnosis and treatment to avert tragedy The anesthesiologist must rely on all of his senses and these with his past experiences and observations, frequently constitute his only diagnostic facilities.

Many of the untoward happenings which call for prompt action in the course of anesthesia are preceded, accompanied, or followed by other happenings of an emergent nature For example, cardiac arrest can be precipitated by anoxia, which in turn may be caused by respiratory depression or obstruction. The treatment of any one of these entails ability on the part of the anesthesiologist to be aware of and to cope with its associated crises The anesthesiologist in addition to choosing and administering the anesthetic agent, is charged with responsibility for the maintenance of circulation of blood and pulmonary ventilation during the operation. Most unforeseen incidents can be related to one or both of these two functions and they will form the basis for the general classification of anesthetic emergencies in the following discussion. Other common emergencies are described under a miscellaneous classification.

EMERGENCIES HAVING TO DO WITH VENTILATION

Respiratory Obstruction Several factors may prevent the free flow of anesthetic and respiratory gases from mask to lung and back. Anatomic obstruction can occur from *relaxation of the structures* in and around the larynx, especially in edentulous individuals. This condition usually can be corrected by insertion of an oral or nasal airway but may require tracheal intubation. The presence of an endotracheal tube should not lull one into a sense of complete security in regard to the patency of

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the airway An endotracheal tube can be obstructed by excessive kinking a plug of mucus or blood, an overinflated cuff or the clenched jaws of the patient if a protecting device is not used The lumen of the endotracheal tube can be occluded by a close fitting mask, the bevel of the tube can lie against the wall of the trachea or the tube may be so long that it enters the right main bronchus, thus preventing ventilation of the left lung

Laryngospasm This can occur with the use of irritating gas mixtures because of the presence of a pendulous epiglottis or because a bit of mucus blood, or vomitus has become lodged on the vocal cords In some cases it is observed during traction on the abdominal viscera Laryngospasm is more commonly seen when parasympathomimetic agents, such as pentothal sodium or cyclopropane are employed than when other agents are used The treatment of laryngospasm if carried out in a calm and organized manner should not result in a fatality The steps of treatment are as follows

1 Note the time No more than three minutes of anoxia should be permitted.

2 Lower the head of the table and remove the causative factor Remove by suction any foreign material from the larynx, reduce the concentration of irritating gas mixtures or cease visceral traction

3 Administer 100 per cent oxygen by mask under a pressure of 5 to 10 mm of mercury or by intermittent compression of the breathing bag of an anesthesia machine

4 If laryngospasm persists and the jaw muscles are relaxed endotracheal intubation can be attempted. If the laryngoscope can be inserted, a ten per cent solution of cocaine hydrochloride sprayed on the larynx will aid in relaxation of the adducted laryngeal structures

5 If however laryngospasm persists and endotracheal intubation cannot be done and if the allotted time of three minutes is nearing its end, tracheotomy may be performed.

Intravenous administration of 0 6 mg ($^1/_{100}$ grain) of atropine sulfate or 6 to 10 mg. ($^1/_{10}$ to $^1/_6$ grain) of d-tuberocurarine hydrochloride has been advocated in the treatment of laryngospasm Whether or not these drugs can produce the desired effect in the short time available is debatable We rarely have had to resort to tracheotomy when we have employed the procedures mentioned in the foregoing numbered paragraphs 1 to 4

Aspiration of Vomitus Vomited material may be aspirated into the tracheobronchial tree This is one of the most feared emergencies with which the anesthesiologist is confronted It can be avoided by using some method of regional anesthesia or by inserting a cuffed endotracheal tube after topical anesthesia of the larynx when a patient with a full stomach must be given general anesthesia. Removal of the solid contents of the stomach by suction before anesthesia is rarely completely successful If vomiting occurs in the course of anesthesia the patient should be placed in Trendelenburg position and all vomitus should be carefully removed with a suction catheter from the pharynx, larynx and trachea, using a laryngoscope for direct visualization To insert the suction catheter through the nose can add to the anesthesiologist's difficulties by causing bleeding. After the respiratory passages have been cleared by suction, a cuffed endotracheal tube should be inserted to prevent future aspiration should vomiting recur When the operation has been

completed, thorough tracheobronchial toilet should be performed, with the bronchoscope or suction catheter inserted into the trachea. Postoperative care of the patient includes administration of humid oxygen by tent or nasal catheter encouragement in coughing and treatment with antibiotics

Respiratory Depression and Paralysis Decrease in effective ventilation occurs in the course of anesthesia following preoperative excessive sedation or following administration of an overdose of anesthetic agent, with consequent depression of the respiratory center Ventilatory decrease may occur also following the use of a large quantity of a preparation of curare or when spinal anesthesia affects high segmental levels paralysis of the muscles of respiration may occur in either set of circumstances

Fortunately respiration is adversely affected in most instances before circulation has been materially impaired, and the problem becomes primarily one of maintaining ventilation by artificial means until the effect of the offending agent has been dissipated Effective ventilation can be maintained by rhythmic compression of the rebreathing bag of an anesthesia machine while the patient is being supplied with oxygen by mask. It is often necessary to insert an endotracheal tube to insure a free airway When overdosage with an inhaled anesthetic agent has occurred, the breathing bag should be emptied and refilled with oxygen at frequent intervals Circulation rarely will fail if oxygenation and removal of carbon dioxide are adequate, unless dosage has been grossly excessive Analeptics have little place in the treatment of patients who have received an excess of anesthetic agent, since these preparations can increase the oxygen requirements of the central nervous system at a time when the supply of oxygen, and the ability to utilize the oxygen available may be decreased.

If narcotics such as derivatives of opium, or nonopiate analgesics such as meperidine hydrochloride or methadone hydrochloride[1] are given in over doses intravenous administration of 5 to 10 mg (1/12 to 1/6 grain) of n-allyl normorphine hydrochloride can reverse the resulting ventilatory depressant effects Intravenous administration of 0.5 to 1.0 mg. (1/120 to 1/60 grain) neostigmine methylsulfate or 10 to 20 mg. (1/6 to 1/3 grain) of edrophonium chloride (tensilon) will diminish the effects of curare on the myoneural junction

Cerebral Anoxia Should a severe anoxic episode occur in the course of anesthesia, prompt recognition and treatment can avert disaster Prolonged and profound anoxia soon will lead to circulatory failure and cardiac arrest. Less severe anoxia will lead to damage to the central nervous system, the degree of which is proportional to the duration and intensity of the anoxia and the tolerance of brain tissue to deficient oxygenation. Delayed recovery from anesthesia, with or without the presence of pathologic neurologic signs leads one to suspect anoxic detriment. Proponents of one concept of cerebral anoxia* have expressed the belief that edema of the brain ensues, which in turn results not only in erection of a barrier to efficient gaseous exchange between cell and capillary but also in progressive depression of the respiratory and circulatory centers. Establishment of such a cycle soon culminates in irreversible harm to the brain tissue and finally in death of the patient.

Interruption of this train of

one or several points will enable one to salvage some of the patients in whom anoxia has occurred. This is effected by increasing the oxygen available to the cell and by decreasing the oxygen requirements of the cell The former can be accomplished by providing an oxygen-rich atmosphere and a free airway with endotracheal tube or tracheotomy thus furnishing adequate pulmonary ventilation by correcting anemia with whole blood by maintaining an efficient circulation with infusion of blood or vasopressor drugs and by eliminating the edema barrier with intravenous infusion of substances capable of increasing the osmotic pressure of the plasma. Solutions of serum albumin in a concentration of twenty five per cent or of dextran in a concentration of twenty per cent, have this property and are administered in doses of 80 to 100 cc to adults or in smaller doses to children at intervals of four to six hours Factors which decrease the oxygen requirements of the cell include maintenance of body temperature at or near normal, avoidance of the use of stimulants to the central nervous system and control of convulsions

Asthma Acute asthmatic attacks occur occasionally in the course of anesthesia. If a patient gives a history of having had asthma, it is wise to avoid the use of morphine preoperatively of parasympathomimetic drugs such as pentothal sodium and cyclopropane, and of agents which are capable of releasing histamine such as curare The expiratory wheeze following aspiration of irritating stomach contents into the tracheobronchial tree must be distinguished from the characteristic wheeze of asthma When an asthmatic attack does occur high concentrations of oxygen should be given and a drug capable of dilating the constricted bronchial muscles should be administered intravenously Epinephrine, 0 12 or 0.2 cc. (2 or 3 minims) in a concentration of 1 1000 or 0.25 to 0.5 Gm (4 to 7½ grains) of aminophylline in 250 cc. of a solution of five per cent dextrose in water is worthy of trial The substitution of ether for whatever anesthetic agent is being used frequently will prevent recurrence of asthma during the maintenance of anesthesia

Pneumothorax In the course of operations on or near the thoracic wall, or of operations high in the abdomen, such as those on the kidney the surgeon inadvertently can incise the parietal pleura. Open pneumothorax results The surgeon immediately should inform the anesthesiologist, and until the pleural defect has been repaired the anesthesiologist should employ the gas machine to maintain an intrapulmonary pressure sufficient to keep the lung on the involved side expanded Occasionally the surgeon will fail to recognize the existence of an open pleural space or may forget to inform the anesthesiologist of it Under these circumstances, the anesthesiologist may first suspect its presence when he experiences difficulty in maintaining adequate oxygenation and when he notices that the patient's respiratory movements are labored The anesthesiologist then should request the surgeon to search for a pleural defect and to repair it if it is present.

A postoperative roentgenogram of the thorax will reveal the presence or absence of persistent pneumothorax. Should a small amount of air remain in the pleural space it can be aspirated with a syringe and needle or a small amount of air in the pleural space of a patient who exhibits no signs of ventilatory difficulty may be left to be absorbed

spontaneously A complete or nearly complete postoperative pneumothorax, which persists or recurs in spite of withdrawal of the trapped air will require that some method of closed drainage be instituted and maintained for twenty-four hours, or until expansion of the lung has taken place as demonstrated by a roentgenogram of the thorax.

EMERGENCIES HAVING TO DO WITH CIRCULATION

Shock The etiology and physiopathology of shock are subject to some dispute It is generally agreed that shock is characterized by a disproportion between the size of the vascular space and the volume of blood in that space That is sufficient enlargement of the vascular space without compensatory increase in the volume of blood, or depletion of the volume of blood without proportionate decrease in the size of the vascular space, can result in shock. Needless to say all gradations from that of normal circulating volume to depletion of blood volume great enough to produce extreme shock can exist, and it is difficult to label a specific point in this series of gradations as that at which true shock occurs Although this simplified conception of shock may not be completely acceptable to all readers, treatment nevertheless is directed toward increasing the volume of blood or decreasing the size of the vascular space

Shock is most commonly characterized by hypotension tachycardia, and cool, pale wet skin. These symptoms may be absent or minimal when shock is impending in a recently injured or chronically ill patient who because of a relatively stable vasomotor system, is able to maintain his peripheral circulation fairly efficiently Anesthetization of such a patient, with resultant depression of his vasomotor centers and responses can result in shock with its typical symptoms Adequate preoperative restoration of the normal blood volume of the injured or chronically ill patient, with infusion of whole blood or of plasma volume expanders, decreases the likelihood of the occurrence of shock as an emergency in the course of operation

In the course of anesthesia and operation shock can occur from the loss of large quantities of blood. This loss can take place suddenly or it may be insidious, owing to constant seepage from raw exposed surfaces The loss can be estimated by weighing the blood-soaked sponges and by collecting in a graduated vessel blood recovered by means of a suction tip Under ideal circumstances blood should be replaced as it is lost. Sudden hemorrhage must be combated by rapid infusion through a needle of large gauge of a quantity of blood comparable to that lost. An apparatus by means of which pressure can be increased in the transfusion bottle will permit more rapid replacement. A simple pressure device, which can be used with most transfusion bottles consists of (1) a needle long enough to reach the air space above the blood when the bottle is inverted, (2) a short length of thick walled rubber tubing, and (3) a rubber bulb such as is used with a blood pressure apparatus The needle and tubing can be connected by a Luer-locking device and can be sterilized. The needle should be inserted through that portion of the rubber plug in the transfusion bottle through which the blood is collected. Pressure cannot be increased in a bottle in which the air inlet diaphragm has been punctured. Massive hemorrhage resulting in profound shock occasionally will require that a needle be placed in an artery and that the blood

be administered rapidly with a pressure device This procedure will fill the arterial circulation rapidly and is said to increase the flow of blood through the coronary and cerebral vessels[3]

All or some of the familiar symptoms of shock occasionally are observed even though little blood has been lost. Those which occur in the course of spinal anesthesia that reaches to high segmental levels are caused by interruption of a large portion of the thoracolumbar autonomic outflow with the result that the size of the vascular space supplied by these nerves is increased Although the symptoms of shock are present and although the volume of blood relative to the vascular space is reduced the label "shock" is not usually applied here Return of the blood pressure to the preoperative level can be accomplished by intravenous administration of one of the many available vasopressor drugs such as ephedrine sulfate in a dose of 12.5 to 25 mg. ($^{5}/_{24}$ to $^{5}/_{12}$ grain) The controlled intravenous infusion of a solution of five per cent dextrose in water and containing 5 mg ($^{1}/_{12}$ grain) of phenylephrine hydrochloride or 2 to 4 mg ($^{1}/_{30}$ to $^{1}/_{15}$ grain) of l-norepinephrine in 1000 cc affords an excellent method of carefully regulating the blood pressure under these conditions It is said that the latter drug is or is very nearly like that actually liberated by the vasoconstrictor nerves at the arteriolar level[4] Needless to say if bleeding of any appreciable quantity takes place in the course of spinal anesthesia, symptoms of shock must be assumed to be attributable to loss of blood rather than to vasodilation, and replacement with whole blood or with plasma volume expanders is desirable.

Episodes of hypotension are observed in the course of operations which involve the abdominal viscera or the hilus of a lung and in the course of operations near the carotid sinus These episodes usually are attributed to irritation of autonomic reflexes mediated through the vagus nerve and are often transient. Persistent hypotension from these causes can be treated by administering vasopressor drugs or by injecting a one per cent solution of procaine hydrochloride around the involved tissue

Cardiac Failure. A patient with heart disease who is able to carry on normal activity usually is able to tolerate anesthesia and most surgical procedures Occasionally the cardiac reserve of such a patient may be so low or the nature of the operation may be such, that sudden cardiac decompensation occurs This serious happening is heralded by acute pulmonary edema, with labored breathing and secretion of a characteristic pink frothy mucus from the alveoli rapid heart rate and increased venous pressure are associated Treatment consists of cessation of administration of the anesthetic agent, inhalation of a high concentration of oxygen by mask under a pressure of 5 to 10 mm. of mercury and intravenous administration of a drug capable of producing full digitalization in a short time Lanatoside C is a valuable drug for this purpose and can be given in a dose of 0 8 to 1 6 mg. ($^{1}/_{75}$ to $^{1}/_{40}$ grain) The application of blood pressure cuffs to the extremities and their inflation to a pressure greater than the venous pressure, will decrease the return of blood to the heart. If improvement does not take place within thirty to sixty minutes, the digitalizing drug chosen should be readministered in a smaller dose Compensation may take place within a few hours or not at all.

Cardiac Arrhythmia Irregularity

: or variation in the cardiac rate can ike place in the course of anesthesia id operation, in the presence of known eart disease or in a case in which car iac disability is not suspected. Suc essful treatment depends on accurate etermination by electrocardiogram of e nature of the arrhythmia Sinus chycardia and bradycardia are usually ot serious and usually need no treat ent, although the anesthesiologist hould assure himself under these con itions that the patient is receiving ade uate oxygen Paroxysmal supraven ricular tachycardia is frequently tran ient and often ceases with termination f the anesthesia. Persistent episodes an be treated with 0.5 to 1 0 mg (1/120 o 1/60 grain) of neostigmine methylsul ate given intravenously Intravenous dministration of procaine amide hy lrochloride in doses of 100 to 500 mg (1½ to 7½ grains) occasionally will erminate the attack.[8] If these measures ail, digitalization may be required. A more serious kind of arrhythmia, and one which may be the prelude to ventricular fibrillation, is ventricular tachy cardia Its onset, in turn, may be preceded by frequent ventricular extrasystoles The treatment of ventricular extrasystoles or tachycardia consists of intravenous administration of 100 to 500 mg. (1½ to 7½ grains) of procaine amide hydrochloride A continuous elec trocardiographic tracing should be made during this administration, and the patient should be observed for hypotension or evidence of convulsions. Another useful drug is quinidine sulfate which can be given intravenously in a dose of 0.3 Gm. (5 grains) or more It should be reiterated that cardiac arrhythmia cannot be treated intelligently until its nature has been ascertained by electrocardiogram.

Hypertension Occasionally a patient who is undergoing anesthesia will experience an excessive elevation of blood pressure This is a frequent, al though not invariable accompaniment of retention of carbon dioxide, with or without hypoxia. Hypertension is observed not uncommonly in the course of operation on the brain or resection of the prostate gland by the transurethral approach. Extreme hypertension and tachycardia, with no obvious causative factor occurring in the course of an operation, may lead one to consider the presence of an otherwise unsuspected pheochromocytoma. The treatment of any of these episodes of hypertension is directed toward the cause Hypertension attributable to accumulation of carbon di oxide will respond to proper ventilation and absorption of the carbon dioxide That caused by liberation of epine phrine or norepinephrine from a pheochromocytoma can be corrected by intravenous administration of 5 to 10 mg (1/12 to 1/6 grain) of an adrenolytic agent (regitine) which is 2-[N-p-tolyl N (m -hydroxyphenyl)aminomethyl] — imidazoline hydrochloride Blood pressure which has risen to an alarming level from other causes can be decreased by the cautious intravenous injection of 0 065 to 0.2 Gm. (1 to 3 grains) of sodium nitrite in solution. Before this treatment is instituted, the anesthesiologist should assure himself that the hy pertension is more dangerous to the pa tient than the hypotension which might ensue

MISCELLANEOUS EMERGENCIES

Hiccup Although hiccup in the course of a surgical procedure is not a serious happening, its occurrence may be distressing to the surgeon who is at

tempting to perform an operation for which a quiet abdomen is required. This condition most commonly follows traction on, or manipulation of the upper abdominal viscera in the course of anesthesia with pentothal sodium and a preparation of curare. Occasionally it can be stopped by increasing the pressure in the breathing circuit to 5 to 10 mm of mercury The addition of carbon dioxide in a concentration of five per cent, or of small amounts of ether or cyclopropane to the inhaled gas mixture is sometimes successful If these measures fail induction of apnea by complete curarization, followed by vigorous artificial respiration usually will terminate this troublesome condition

Spasm of Sphincter of Oddi Not infrequently patients who have undergone cholecystectomy and who since have suffered from biliary dyskinesia, receive the customary sedation with morphine sulfate prior to another operation This drug may cause spasm of the sphincter of Oddi with exacerbation of the distress characteristic of biliary colic Relief can be obtained by intravenous injection of 0 1 Gm (1½ grains) of sodium nitrite

Extravenous Injection Every anesthesiologist has experienced the embarrassment of inadvertently injecting or infusing solutions into the subcutaneous tissue rather than into the intended vein When these solutions are isotonic or closely approach those of the body in hydrogen ion concentration and are injected into loose subcutaneous tissue no harm other than mild discomfort to the patient usually results Occasionally however hypertonic solutions acid solutions, or those of strongly alkaline character such as pentothal sodium are mistakenly injected subcutaneously and may cause necrosis. Infiltration of procaine hydrochloride in a concentration of 0.5 or 1 per cent will decrease the pain may dilute the concentrated solution, and will cause vasodilatation Local application of heat will hasten absorption of the solutions. Even more serious is the injecting of solutions beneath the skin which closely overlies the structures of the antecubital fossa the volar surface of the wrist or the dorsum of the foot In these regions deposits of solutions are closely confined and poorly absorbed so that permanent damage to nearby tendons or nerves, or occasionally sloughing of the skin may result. It is perhaps wiser to avoid the use of these areas for intravenous infusion of astringent or concentrated solutions than to attempt to treat extravenous injection should it occur

Pentothal sodium in solution is alkaline as has been said and if inadvertently injected into an artery occasionally will cause sufficient spasm to produce necrosis of the tissues supplied by that artery Should pentothal sodium be injected into an artery the patient will complain of a burning sensation extending peripherally from the point of injection The more serious implications of intra-arterial injection of pentothal sodium can be avoided by using solutions which have no greater concentration than 2.5 per cent and by injecting a small test dose initially

Shock Following Stress After Withdrawal of Cortisone [8] The prolonged administration of cortisone to a patient may produce atrophy of the adrenal cortex and depression of its function. This may persist for several weeks after treatment with this substance has been stopped Patients on whom the stress of anesthesia and surgical operation is to be imposed should be questioned in regard to recent cessa

tion of treatment with this preparation. The temporary adrenocortical insufficiency which under these circumstances occasionally exists can lead to shock in the course of the operation or in the immediate postoperative period. Patients concerning whom adrenocortical suppression is suspected can be subjected to the stress of surgical operation with relative safety if they are given *100 to 200 mg* (1½ to 3 grains) of cortisone intramuscularly for two days before operation and in gradually decreasing doses for several days after operation. Should shock nevertheless occur in the course of or immediately after operation, 50 cc. of adrenal cortical extract should be given intravenously and the administration should be repeated as necessary along with other *supportive materials* such as blood plasma volume expanders, and vasopressor agents. The response to cortisone administered intramuscularly is slow in onset however cortisone and related steroids suitable for intravenous use may be found efficacious in the rapid treatment of shock attributable to adrenocortical suppression or to other causes.

SUMMARY

The primary role of the anesthesiologist in the surgical team is to administer the anesthetic agent to the patient. Nearly all of his other functions are concerned with assuring the patient of adequate supplies of oxygen to his tissues and elimination of carbon dioxide This necessitates the presence of adequate oxygen in the mask, a free airway and either active or passive respiratory movements to insure an oxygen-rich atmosphere in the alveoli It necessitates a circulation of blood sufficient to carry oxygen from the alveoli to the tissues, most important of which are those of the brain and the heart. It necessitates *satisfactory transfer of oxygen* from the capillaries to the individual cells of those tissues Most of the calamitous emergencies with which the anesthesiologist is confronted result from the failure of one or more of the steps in this train of events As is always true, prevention is better than treatment The good anesthesiologist will be able to treat each emergency as it arises. The better anesthesiologist will avoid them by anticipating recognizing, and correcting initiating factors

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57

Acute Postoperative Psychosis

THE modern surgeon is profoundly interested in the postoperative course of his patients after major operations Certain complications are the source of much concern to him. One of the most unusual and least frequently encountered is the development of mental symptoms during convalescence.

An excellent classification of post operative mental disturbances has been made based upon the relative importance of organic and psychogenic factors in their causation The three categories are

1 Toxic reactions with delirium in patients who have never previously had any disorder of the central nervous system.

2. Toxic reactions with delirium in patients with preexisting disorders of the central nervous system

3 Psychotic manifestations of functional origin traceable to the effects of a surgical procedure

During the past few years we have encountered three patients who have displayed mental confusion after major operations These patients were of the type previously classified

REPORT OF CASES

Case 1—Mrs L. B., a thirty-five year old white housewife was admitted to the hospital for elective cholecystectomy She had many acute exacerbations of gallbladder symptoms The cholecystogram demonstrated four large calculi in the gallbladder Her past history was noncontributory She had had four children with four pregnancies There was no previous neuropsychiatric history

A cholecystectomy was performed successfully Convalescence was satisfactory until the second evening after operation when the night nurse reported that the patient was delirious Gradually during the next twenty four hours she became moody and disoriented occasionally falling into a stupor Restlessness, purposeless motions of the legs and carphologia (picking at the bed clothes) were prominent symptoms of her mental unrest

At the onset of these manifestations, the nurse thought the patient merely ignorant or stupid. A competent psychiatric examination however revealed the underlying cause The diagnosis of toxic delirium was made The patient was moved to a psychiatric institution where she remained for one month and was then discharged

Case 2—Mrs C. B a thirty five year old white housewife was seen for the first time as an office patient She was a native of Virginia where her family

physician had prepared her for thyroidectomy She had severe primary hyperthyroidism At the time of examination her right arm was in a plaster cast because of a fracture of the shaft of the humerus Her husband stated that they had been in an automobile accident enroute to New York, but later it was determined that her injury was due to a fall suffered during an episode of violent emotionalism. The patient was a Christian Scientist, and medication was administered by subterfuge Her husband mixed the Lugol s solution with her milk. Her entire attitude was negativistic Shortly after this visit the patient was admitted to the hospital for thyroidectomy No unusual complications were encountered until the second postoperative day The patient became violent, requiring special nurses mechanical restraints and side rails on the bed. Sedation was given rectally in the form of paraldehyde The patient was transferred to a psychiatric hospital, where she was confined for several months

Case 3—Mrs. M. A., a fifty year old white housewife, was transferred from a city hospital to our service. Her abdominal findings suggested the presence of acute cholecystitis with adynamic ileus After adequate preoperative preparation, operation was performed. Acute pancreatitis was observed The gallbladder was markedly distended, with a calculus embedded in the cystic duct. A cholecystostomy was performed.

On the morning of the third postoperative day the patient had "peculiar" muscular movements which were interpreted as tetanic twitching. Calcium gluconate was given parenterally During the night the patient became restless The house officer gave her morphine which was followed by a severe boisterous reaction This injudicious use of sedation so aggravated the delirous state that she was transferred to a County Hospital where she died six days later

COMMENT

The cases presented exemplify the various types of mental disturbances occurring during the postoperative period

In the first instance the patient exhibited the type of toxic delirious reaction seen in persons who show no evidence of preexisting disease of the central nervous system.

The treatment of such conditions centers upon adequate nutrition (by gavage if necessary) and sedation as required. The avoidance of narcotics, such as morphine and the judicious administration of paraldehyde orally rectally or intravenously are beneficial Restraints are employed when needed Early ambulation, when possible, is preferable to prolonged bed rest. Quiet, restful surroundings, including adequate lighting, are essential.

The second case illustrates a preexisting mental state aggravated by surgical treatment in a patient with hyperthyroidism. The psychic component of thyroid disease is too well known to require emphasis here The mental balance of this patient was further strained in that she was antagonistic to medical and surgical treatment because of her religious beliefs. The results of psychiatric treatment were retarded for the same reason.

The third case illustrates a major functional psychosis precipitated by surgical trauma "It is believed that this type of reaction is largely determined by the patient s previous personality This is usually seen in either a schizo-

phrenic or a manic-depressive character."[1] When evidence of a functional psychic reaction emerges the patient may be transferred to a psychiatric institution for therapy It is preferable however whenever possible to allow the patient to remain in the same hospital.

In spite of the death of our third patient the prognosis for ultimate recovery in acute postoperative psychoses is usually good -

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SECTION IX

SURGICAL EMERGENCIES SEEN IN CERTAIN GROUPS OF PATIENTS AND THE TREATMENT OF HUMAN AND ANIMAL BITES

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58

Subphrenic Abscess

WIDESPREAD use of chemotherapy and the antibiotic drugs has resulted in a significant decrease in the incidence of subphrenic infection and subphrenic abscess formation. Subphrenic abscess however still remains one of the commonest and the *most important* of the complications of suppurative processes originating within the abdominal cavity The mortality is high in instances where the diagnosis has been delayed or the treatment has been inadequate

Etiology That subphrenic abscess is primarily a complication of an intra-abdominal suppurative process is adequately supported by the fact that, of 3608 collected cases, Ochsner and DeBakey *found that* the primary lesion originated in the abdomen in eighty four per cent of the cases. The processes responsible for subphrenic infection in order of frequency are (1) infections originating in the appendix, (2) infections extending from lesions of the stomach or the duodenum, and (3) infections arising in the liver and the biliary tract. Metastatic infection of the subphrenic spaces by way of the blood stream or the lymphatic circulation from distant focus is encountered in rare instances Extension of suppurative intra *thoracic lesions* into the subphrenic spaces and infections secondary to abdominal or thoracic trauma are very unusual causes of subphrenic abscesses

The organisms responsible for subphrenic infection are variable Frequently mixed aerobic and anaerobic strains are encountered The location and the organ involved in the primary inflammatory process are important factors in determining the virulence and the character of the secondary subphrenic suppurative infection. In a series of cases reported by Lehman and Archer the *Bacillus coli* was present in 29 4 per cent, the streptococcus in 23 4 per cent, and the staphylococcus in 23 4 per cent of the cases

The mechanism by which the original infection spreads to the subphrenic spaces is variable and may follow any one or more of the following routes (1) By direct extension from the peritoneal cavity or indirectly from the peritoneal cavity or from a contiguous extraperitoneal organ, (2) through the portal vein and its radicles (3) by way of the abdominal lymphatics or as previously mentioned, (4) by blood borne *metastasis* from an infection anywhere in the body

Most surgeons agree upon the *method* by which lesions *arising in contiguous* organs infect the subphrenic spaces but

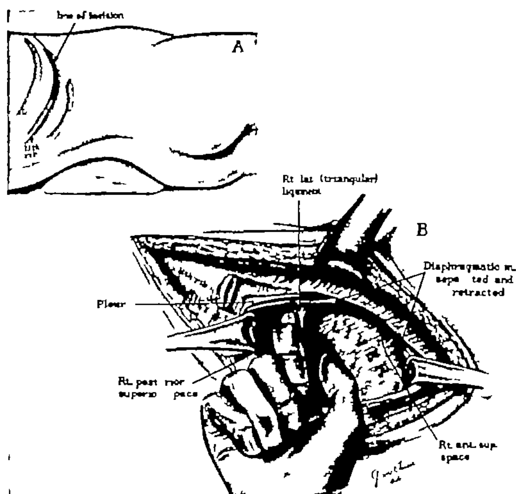


FIG. 1

there are differences of opinion regarding the mode of extension from distant intra abdominal foci Ullman and Levy Lockwood Melchior and Melchior and Oschner believe that entrance to the subphrenic space may be gained by ex tension of infections from the right iliac fossa through the gutter between the ascending colon and the lateral parietal peritoneum DeBakey and Oschner and Overholt and Donchess attribute the frequency of involvement in the supra hepatic region as compared to the infrahepatic region, to local and mechanical factors The infrahepatic space communicates freely with the general peritoneal cavity whereas the suprahepatic space may be considered as closely approaching a closed space and for this reason is more conducive to the devel opment and progress of infections This process is further enhanced by the presence in this space of a negative pressure created during respiration Lehman and Archer feel that this is unlikely and base their opinion upon the contention that, after a peritoneal inflammatory reac tion is established, there is little possi bility for fluids to flow Moreover this mode of extension is not consistent with the frequency of involvement above the dome of the liver without involvement

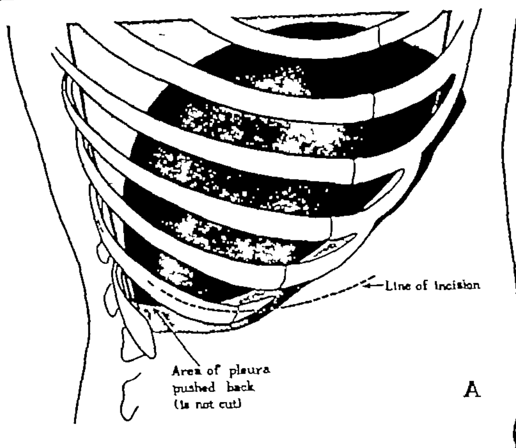


Fig 2

in the subhepatic region. Munro has emphasized the importance of the retroperitoneal lymphatics as a pathway of infection from the abdominal viscera to the subphrenic spaces The validity of this hypothesis has been further supported by the work of Truesdale and Barnard. It is probable however that the great majority of cases result from a combination of these methods of extension.

Anatomy of Subphrenic Space: Martinet, Barnard, Oschner and Thorek have described the anatomy of the subphrenic space in great detail. Their contributions are summarized here for the purpose of orientation before describing the technic of subphrenic abscess drainage The subphrenic space is defined as the space lying between the diaphragm above, and the transverse colon and the transverse mesocolon below This large space is divided by the liver into the suprahepatic and infrahepatic spaces. The suprahepatic space is subdivided by the falciform ligament of the liver into right and left spaces The right coronary ligament and its lateral extension divides the right suprahepatic space into two spaces, a large anterior one and a smaller posterior one Thus, in the suprahepatic region there are three spaces, the right anterior superior subphrenic space, the right posterior subphrenic space and the left superior subphrenic space.

The infrahepatic area also is divided into the three subphrenic spaces and

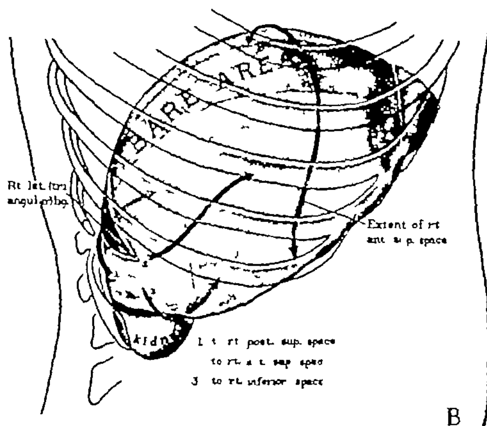


FIG. 3

into right and left sides by the round ligament of the liver and the ligament of the ductus venosus. The large space to the right of the round ligament which is bounded above by the inferior surface of the liver and below by the transverse mesocolon and colon is known as the right inferior subphrenic space. To the left are two spaces separated from each other by the stomach and the gastrohepatic omentum. The area anterior to the stomach bounded above by the left lobe of the liver and below by the transverse mesocolon and colon is the left anterior inferior subphrenic space. The left posterior inferior subphrenic space lies behind the stomach and gastrohepatic omentum. It is bounded above by the liver and posteriorly by the parietal peritoneum of the lesser sac.

Treatment. When the existence of a subphrenic abscess seems certain, surgical drainage is indicated without delay. The operation of choice is the one that permits adequate dependent drainage of the abscess cavity with least possible contamination of the pleural or peritoneal cavities. An extraserous approach is desirable and it may be either transthoracic or transabdominal. The incision used to accomplish drainage depends to some extent upon the location of the abscess that is to be drained.

Oschner and Graves in 1933 standardized the approach to abscesses in the various subphrenic spaces. Because the

posterior superior phrenic space was the one most frequently involved, they advocated an incision through the bed of the twelfth rib Melinkoff has shown that in ninety two per cent of the cadavers examined by him the costophrenic angle of the pleura on the right side either completely covered or touched the twelfth rib somewhere in its course. For this reason and because of the depth of the right posterior superior space when approached through the back, a lateral incision through the bed of the excised eleventh rib is advocated On the right side, this incision gives access to the anterior and posterior superior subphrenic spaces as well as the right inferior subphrenic space The approach is equally effective in gaining access to the left superior and left anterior and posterior inferior subphrenic spaces

Under intratracheal anesthesia, with the patient lying on the unaffected side with a sand bag placed in the lumbar region so that a scoliosis of the lower dorsal and upper lumbar spine is produced, an incision is made over the entire eleventh rib and extended anteriorly for a variable distance The eleventh rib is resected subperiosteally The incision is carried down through the anterior one-third of the eleventh rib bed. The relation of the costophrenic angle to the eleventh rib varies considerably in different individuals Rarely does the costophrenic angle extend ventrally as far as the tip of the eleventh rib The lower fibers of the diaphragm are incised transversely and the pleura is retracted upward and posteriorly In those cases in which the posterior superior space is suspected the posterior parietal peritoneum is reflected downward under direct vision by blunt dissection with the finger Separation of the same cleavage plane in an anterior direction gives access to the right anterior superior space and if the left side is affected, to the left superior space In instances where infrahepatic space infections are suspected, the renal fascia and kidney on the affected side are reflected downward in a posterior direction and the parietal peritoneum reflected downward and anteriorly As has been suggested by Graves and Oschner aspiration in locating a deep abscess is helpful as long as one is certain of the location of the pleura and parietal peritoneum

Through this incision adequate drainage of one or a combination of all of the subphrenic spaces may be accomplished The approach is especially advantageous for suprahepatic space infections because many subhepatic infections can be drained by a simple extraperitoneal incision placed beneath either costal margin

When the abscess cavity is encountered all loculations are divided by blunt dissection with the index finger and Penrose drains placed in the dependent portions of the involved space. The wound is loosely closed with catgut and silk sutures extending to and beyond each drain

During convalescence in addition to general measures to rehabilitate the patient, chemotherapy and antibiotic medication should be continued The size of the abscess cavity may be followed by roentgen examinations after the injection of any nonirritating radiopaque substance.

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Acute Surgical Emergencies in Infancy and Childhood

IN reviewing this subject a narrow and specific interpretation has been employed, thereby avoiding discussion both of those acute surgical conditions seen more commonly in adults and of those lesions that are more appropriately dealt with in other chapters.

That the surgical care of infants and children involves many peculiar problems is evidenced by the present-day development of pediatric surgery as a specialty The labile physiologic processes of these small and immature subjects withstand the stresses of surgical trauma less effectively than adults Fluid and electrolyte imbalance is poorly tolerated and resistance to infection is frequently of a low order Consequently it behooves the general surgeon to familiarize himself not only with the surgical conditions peculiar to pediatrics but also with the many general considerations involved in pre and postoperative care

Preoperative Care: It is a rare surgical emergency that precludes attention to preoperative disturbances of physiology Significant alterations in fluid-electrolyte balance develop commonly and within a short period of time Severe dehydration and alkalosis or acidosis resulting from protracted vomiting and/or diarrhea may develop in a few hours In such cases blood chemistry studies are frequently of little practical value whereas an accurate history regarding the duration and amount of vomiting or diarrhea, plus clinical observation, permits accurate estimation of fluid-electrolyte losses The intravenous and subcutaneous administration of fluids to infants at a rate not exceeding 60 cc./hr may be done with safety Whole blood may be given in amounts of 20 to 30 cc./kg. at a single infusion. Since complete repletion may not be accomplished before emergency surgery the therapy should be continued during and immediately after the operation Occasionally it is necessary to cannulate a vein with polyethylene tubing to facilitate administration of fluids Blood transfusion during and after surgery is of great supportive value In general, these young subjects tolerate imbalances poorly but, conversely the correction of these deficiencies can usually be achieved more readily than in adults

One should be aware of the presence of marked anemia which, if not correctable because of the urgency of opera-

tion can be treated postoperatively and concomitant hypoproteinemia should likewise be corrected, inasmuch as both deficiencies mitigate against proper wound healing.

Inasmuch as acute abdominal pain is frequently a symptom of nonsurgical disorders in childhood a thorough study of each case is mandatory before surgery is contemplated Various exanthematous diseases, pneumonia, diabetic acidosis rheumatic fever and sickle-cell anemia crisis are but a few of the medical conditions associated with severe abdominal pain and vomiting Erroneous diagnosis and unnecessary surgery occasionally followed by a serious or fatal outcome can be avoided only by intimate cooperation of the pediatrician and surgeon

Operative Technic: Careful attention to the details of operative technic is essential in the field of pediatric surgery The tissues are delicate often abnormally so by reason of faulty development or because of the underlying pathology Not infrequently anatomic relations and landmarks are obscured. It is necessary to use instruments of sufficiently small size to minimize trauma to tissues, and no compromise should be made in this regard. One should refrain from crushing large bites of tissue with clamps and the use of sharp dissection is desirable

Incision should be sufficiently large to enable the surgeon to carry out the contemplated procedure with ease but inordinately large incisions, particularly in abdominal surgery pose a greater potential danger of postoperative wound dehiscence or the development of an incisional hernia Use of transverse incisions, whenever possible is highly recommended Closure of operative wounds should be done with meticulous care because of the occasional tendency toward poor wound healing. In general, absorbable suture materials are preferred. However in older children and when the incision is necessarily large the use of nonabsorbable sutures is advised In the presence of gross infection or contamination, absorbable sutures offer less chance of persistent wound drainage

Anesthesia* Anesthesia for the child undergoing emergency surgery covers a rather broad field The newborn has special problems of its own but these disappear gradually with age and the well-developed child of eight approaches the adult in physiology and in reaction to anesthetic management.

In the neonatal period and in early infancy we should remember "the disadvantage of being small."[1] The increased surface area in proportion to the body mass, reflects itself in increased metabolic rate, heat production and insensible water loss, together with a comparatively small amount of extracellular fluid In addition to this, the thermal regulating mechanisms may be deficient in early infancy Accordingly attention should be sharply focused on the state of hydration of these patients particularly when fluid loss by diarrhea and vomiting has been coupled with high body temperature. These are the patients who convulse and not infrequently die during anesthesia

Recent trends in premedication have shown that drugs which are of use for the adult are useful in pediatric surgery and for the same reasons The details of premedication are beyond the scope of this presentation, but have been well outlined by Leigh and Belton The

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nber this figure that a 3 kg new born has but 240 cc of circulating blood To such a patient, the loss of 50 cc. of blood may be catastrophic On the other hand, rapid infusion of 200 cc. of parenteral fluid may be equally disastrous Here again preparedness must be stressed Venipuncture is not readily done in the shocked infant. With any suspicion of anticipated blood loss, a cut-down on a vein is mandatory The time consumed is well spent.

In brief these are cases where preparedness in all aspects will pay big dividends Conversely the cutting of corners and lack of attention to minute details will lead to disappointing results

Postoperative Care· Close observation of operative wounds is necessary in the postoperative period. In infants particularly soiling of the wound by urine or feces must be minimized. The use of collodion over the incision is effective in minimizing contamination and eliminates frequent re-dressing with its attendant contamination potential. Often the use of leg or arm restraints is necessary to prevent these young patients from disturbing the dressing. Care must be used in the application of such restraints to avoid injury as a result of excessive pressure In certain instances, the application of a plaster cast rather than cloth restraint may be warranted to protect the operative site

The early resumption of a regular diet is desirable particularly when some degree of nutritional disturbance exists preoperatively It is difficult to maintain infants with total parenteral alimentation they rapidly lose weight. As soon as conditions permit, water and dilute formula should be offered Small amounts given at frequent intervals are more readily retained, following which the amount and interval can be increased gradually Return of appetite in

older children occurs promptly after most surgical procedures and often the problem is adequate restriction of intake in the early postoperative period.

HEAD AND NECK

Not infrequently the surgical care of certain conditions occurring in this region assumes emergency features Of particular importance in this regard is the relative ease with which an adequate airway may be interfered with in the infant or growing child.

A depressed fracture of the skull may follow relatively slight trauma because of the incomplete development of the skull bones Small depressions may produce serious focal brain damage. Early operative treatment is advisable, and simple elevation of the depression usually will suffice. Compound wounds should receive meticulous cleansing to minimize the possibility of meningitis.

The removal of *foreign bodies* from the nasal passages and auditory canal must be carried out with extreme care Certain hygroscopic materials *e.g.*, peas, beans must be removed promptly because they tend to swell, making removal difficult. Installation of a small amount of carbolized petrolatum will *effectively kill insects and facilitate their* removal Forceful manipulation is to be avoided in order to prevent damage to the eardrum or the forcing of a foreign body into the nasopharynx with subsequent aspiration Anesthesia is usually unnecessary although the use of 2 5 per cent cocaine locally may be helpful

Severe *lacerations of the tongue resulting in hemorrhage or marked func*tional disturbance should receive early surgical care Securing hemostasis and approximation of the wound edges will suffice Infection is uncommon and may be allayed by use of an antiseptic mouthwash several times daily

Peritonsillar and retropharyngeal abscesses are uncommonly encountered since the advent of antibiotics. When such an abscess does develop the child is often acutely ill and toxic, and surgical drainage becomes necessary to relieve progressive pharyngeal obstruction Peritonsillar abscess is readily diagnosed by inspection. Retropharyngeal abscess is more insidious in its development, and the gravity of the situation becomes evident only when difficulty in breathing occurs These patients assume a characteristic posture, with the neck extended, and respiratory stridor is conspicuous Diagnosis is confirmed *by digital examination of the pharynx.* Incision and drainage is done under general anesthesia extreme care being taken to prevent aspiration of purulent material

Cystic hygroma of the neck a congenital lesion, occasionally requires emergency surgery Sudden expansion of the mass *e.g* due to hemorrhage into the cyst, may cause severe tracheal compression Incision and drainage is urgent to relieve such obstruction Elective operation to excise these cysts is *advisable to avoid recurrence* and infection.

Ludwig's angina an acute infectious process beginning at the gingival margin or the floor of the mouth, may become a surgical emergency if the edema obstructs the oropharynx or extends to the larynx to produce obstruction Tracheotomy should be done as soon as any *appreciable respiratory difficulty* occurs The severe inflammatory process usually localizes sublingually and if fluctuation occurs incision and drainage is *indicated.* The cervical cellulitis should

regress with antibiotic therapy and/or surgical drainage of the sublingual abscess *Incision and drainage of the cervical cellulitis is usually not indicated*

THORACIC SURGICAL EMERGENCIES*

The thoracic surgical emergencies of infants and children may be divided into those of congenital origin and those which are acquired. The congenital group fortunately is infrequent in its occurrence. Among the acquired group some are relatively common, and these will be considered first.

Atelectasis. Atelectasis is the most frequent of thoracic surgical emergencies. It is most often seen in the newborn where failure of expansion has occurred in a segment of the lung due to plugging of a bronchus by mucus or occasionally as a result of aspiration of either milk or gastric contents. The diagnosis is to be suspected clinically on the basis of cyanosis or respiratory difficulty Verification can be obtained by physical signs and x-ray findings The treatment is the removal of the material obstructing the bronchus. This is most readily carried out by using the laryngoscope to visualize the larynx and the passage of a small catheter into the trachea. By properly directing the catheter one can pass it down each main stem bronchus and as far peripherally as the catheter will go By using a small size catheter adequate aspiration can be obtained It may be necessary to repeat this process until one can again hear good breath sounds in the previously blocked segment and to demonstrate the expansion of the segment by x rays The use of a head-down position promotes drainage and tends to prevent blockage of the bronchus If adequate clearing is not obtained bronchoscopy is necessary

Acute Laryngotracheobronchitis Acute laryngotracheitis is another of the *common diseases* which may on occasion require immediate surgical intervention, *i.e* when it becomes apparent that there is severe obstruction to the upper air way The difficulty in securing adequate respiratory exchange is apparent in these patients and is manifested by a considerable degree of retraction on respiratory effort, stridor and cyanosis associated with a rapid respiratory rate. Children who are seen with laryngotracheitis prior to the onset of severe respiratory difficulty may be treated with the usual conservative measures However they must be watched carefully for the development of obstruction to the upper air passage In the era in which diphtheria was common diphtheric laryngitis produced similar blockage of the larynx, and occasionally one sees such a case even now

Tracheotomy is the immediately indicated therapy It should be emphasized that this had best be done electively when obstruction becomes evident and before the patient is in the terminal stages of asphyxia Because of the ready invasion of the mediastinal structures in infants and children, a high tracheotomy should be made through the second or third tracheal ring below the cricoid cartilage In making the incision for the tracheotomy care should be taken not to open the superior mediastinal structures from the neck. As soon as the trachea is opened, the air way may be reestablished by spreading

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the cartilaginous rings with the base of the scalpel while the intratracheal tube is inserted Suction should be repeated frequently through the tracheal tube in order to maintain a clear air way and to prevent the development of atelectasis from the retention of secretions. The maintenance of a humid atmosphere following the tracheotomy may be very helpful It is important to secure the position of the tracheotomy tube until the upper air way has been well re established, and the danger of atelectasis is controlled Patency of the air passages should be demonstrated by plug ging of the tracheotomy tube without provoking further respiratory difficulty

Foreign Bodies in the Tracheobronchial Tree and Esophagus The tendency of children to insert all available objects into the mouth leads to the high incidence of ingestion or inhalation of foreign bodies When such an object has been placed in the mouth any unusual stimulus or circumstance may cause the sudden inhalation or swallowing of the foreign body If this material enters the tracheobronchial tree, it is usually evident immediately either by interference with respiration or a spasm of coughing which may be fairly prolonged. If the foreign body is of sufficient size partially to block the larynx, laryngeal spasm may occur wth imme diate block of all respiratory exchange Rapid intervention and removal of the foreign body is necessary to save the in dividual unless as commonly occurs, the onset of laryngeal spasm will dis lodge the foreign body either upward or downward Placing the child in the head-down position may also help to dislodge this material. The immediate introduction of a laryngoscope is indi cated if the symptoms suggest its location in the larynx. If the foreign body has passed into the trachea or bronchus, its removal should be carried out by means of the bronchoscope as soon as it is feasible Fortunately most mate rials which will pass the larynx readily are rather small and produce no imme diately urgent interference with the total respiratory exchange Objects such as nuts, twigs small beans, and other radiolucent materials may make localization of the foreign body impossible by x-rays. However reaction to these materials and block of a segmental bronchus or a main stem bronchus may soon give direct evidence of difficulty by the presence of atelectasis by x ray Occasionally a foreign body may enter the tracheobronchial tree with very little coughing or other evidence of its presence and may be detectable only by unexplained atelectasis In all these instances where inhalation of a foreign body is even suspected the use of bronchoscopy and removal of the foreign body in this fashion should be carried out. It is important that one suspect the presence of a foreign body in any otherwise unexplained atelectasis. In the case of foreign material which lodges in the esophagus the situation is also urgent and is ordinarily manifested by either the inability of the child to swallow food or fluid or by pain in the low neck or upper chest Unless such for eign bodies are removed soon after in gestion, there is danger of perforation of the esophagus with mediastinitis Sharp foreign bodies which may penetrate the esophagus offer a special problem but if they are removed immedi ately difficulties are minimized The commonest sites of lodgement of for eign bodies in the esophagus are at the cricopharyngeus area and at the junction of the esophagus with the stomach. General anesthesia is required for the

removal of all such foreign bodies in children and an experienced endoscopist can usually carry out the procedure without difficulty

Acute Pericarditis Acute pericarditis may sometimes be confused with other acute intrathoracic and intra-abdominal conditions It is not uncommon that the major pain associated with acute pericarditis in infants and children may appear to be in the upper abdomen Such pericarditis is of surgical importance only when the pericardial effusion is of such magnitude as to produce cardiac tamponade The pericardium may be aspirated through the paraxiphoid space or through the fifth interspace just to either side of the sternum However operative intervention for drainage is preferable to needling of the pericardium in most instances This can be readily carried out as an extrapleural procedure By making a small incision just at the level of the xiphoid and separating the insertion of the recti from the xiphoid process the plane of dissection can be developed extraperitoneally and extrapleurally The dissection is carried up to the base of the pericardium. The pericardium can then be opened under direct vision and the fluid drained. This allows for visualization of the pericardial sac so that damage to the vessels of the myocardium can be avoided. This procedure can be carried out under local anesthesia with no particular difficulty and offers the safest measure for pericardial drainage

Congenital Anomalies. Tracheoesophageal fistula is one of the serious emergencies among the congenital anomalies If the proximal segment of the esophagus communicates with the trachea the aspiration of food into the tracheobronchial tree through the fistula offers ideal conditions for the development of extensive pneumonitis The use of barium to outline the esophagus in cases which are suspected of this lesion is contraindicated. Lipiodol or iodochoral offers a safe and simple method for the demonstration of this anomaly The constant secretion of saliva makes for the continued aspiration into the trachea The treatment of choice is closure of the tracheoesophageal fistula and reconstruction of the esophagus by direct anastomosis In some instances the esophagus may be intact, and only a tracheoesophageal fistula is present. This type of anomaly lends itself very readily to surgical closure of the fistula and repair of the esophagus However when esophageal atresia is also present, as is very commonly the case reconstruction of the esophagus may offer a serious problem Every effort, however should be made to accomplish an end-to-end anastomosis of the esophagus If atresia of the entire lower segment is present so that great difficulty is experienced in bringing the ends of the esophagus together an esophagogastrostomy can be performed by pulling the stomach into the chest, although this is, in general not a very satisfactory procedure Conservative treatment in cases in which anastomosis cannot be performed would dictate that a cervical esophagostomy be established after the closure of the fistula If esophageal atresia is present alone without tracheoesophageal fistula, the danger of pneumonitis from aspiration of saliva is still present and an immediate cervicoesophagostomy is the treatment. The establishment of a gastrostomy as a secondary procedure should then be carried out twenty-four to forty-eight hours later Reconstructive surgery with the use of a jejunal loop or a cervical esophagogastrostomy may then be performed at a later date.

Cystic Disease of the Lung: In cystic disease of the lung the cysts may communicate with the bronchi and rapidly fill with air in the early days or weeks of life to such a degree that they seriously impinge upon the mediastinum and displace the heart so that auricular filling is poor and there is compression of the lung of the opposite side. The valvular type of opening of the bronchial communication into the cysts may prevent emptying of these air sacs during normal expiration. As an immediate temporizing measure some have recommended the drainage of such cysts by the use of an underwater seal or by simple aspiration. However direct operative intervention will ordinarily solve this problem much more satisfactorily particularly since some cysts may be infected, and drainage results in empyema. Resections of such cystic lungs have been accomplished as early as the fifteenth day of life and excision of the involved lung tissue is the treatment of choice.

ABDOMEN

In no other phase of abdominal surgery does the age of the patient offer as much aid in diagnosis as in pediatric patients. Certain surgical emergencies are strictly peculiar to the early weeks of life whereas others develop characteristically during the first two years and others from two to thirteen years of age. For this reason, those surgical conditions occurring in the newborn during infancy and during childhood will be considered separately.

Newborn: During the first month the majority of congenital anomalies of the intra abdominal organs become apparent. Many of these constitute urgent emergencies requiring prompt surgical relief.

Omphalocele: an uncommon malformation encountered in the newborn, consists of a herniation of intraperitoneal viscera into the base of the umbilical cord. The protruding viscera have only a thin covering composed of amniotic membrane and peritoneum while the abdominal skin stops at the base of the omphalocele. Rupture of this thin covering of the sac occurs early with inevitable and usually fatal peritonitis. For this reason early operative treatment is mandatory. The operative procedure consists of replacement of the viscera into the peritoneal cavity, excision of the sac, and closure of the abdominal wall. The increased intra abdominal pressure resulting from replacement of the viscera may cause serious impairment of cardiac and/or respiratory function. If it is impossible to close the abdominal wall in layers without provoking such embarrassment, the closure should be limited to approximating the skin only. The resulting incisional hernia can be repaired after an interval of two to four weeks. Without surgery the mortality associated with omphalocele is 100 per cent while early operative correction is attended by forty to fifty per cent mortality.



Fig. 1. Diaphragm causing atresia of stomach.

Congenital atresia of the gastrointestinal tract is clinically manifest at or shortly following birth and requires early operative relief. Although the distal duodenum, ileum, and distal rectum are the common sites of atresia, any part of the gastrointestinal tract may be involved.

(a) *Atresia of the stomach* is rare. In a single case of our series a reduplication of the gastric mucosa presented an obstructing diaphragm across the lumen of the distal stomach. After gastrotomy and division of the diaphragm the obstructing symptoms were completely relieved (Fig. 1).

(b) *Atresia of the duodenum* usually involves the third portion of this organ. The onset of vomiting shortly after birth, dehydration, conspicuous absence of distention and the roentgenologic demonstration of obstruction to the progress of a *thin barium mixture in the duodenum* are important diagnostic criteria. Although a gastrojejunostomy may be successfully employed, resection or side tracking of the stenotic area by means

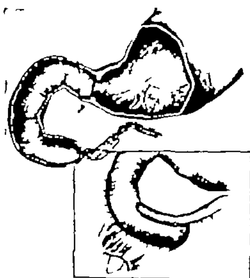


FIG. 2. Resection of the stenotic area in atresia of the duodenum with side-to-side duodenojejunostomy.

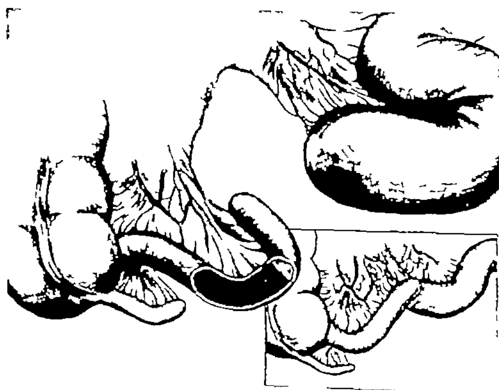


FIG. 3. Primary anastomosis for atresia of ileum.



Fig. 4 Roentgenological visualization of the gas-filled rectal pouch in the inverted position in imperforate anus.

of a side to-side duodenojejunostomy is the procedure of choice This type of anastomosis is preferable because of the disproportion in the size of the dilated proximal and collapsed distal bowel (*Fig.* 2)

(c) *Atresia of the ileum* is associated with progressive abdominal distention roentgenologic evidence of small bowel obstruction on plain film examination and absence of bowel movements Microscopic examination of the meconium will usually reveal the absence of swallowed vernix cells (Farber's test) Vomiting occurs only after four to five days Primary anastomosis with or without resection of the atretic bowel is indicated (Fig 3)

(d) *Imperforate anus* is usually associated with some degree of rectal atresia This anomaly is evident on anal examination and the extent of the rectal defect may be demonstrated by roentgenologic visualization of the gas-filled rectal pouch in the inverted position (Fig 4) In its simplest form the defect consists merely of persistent anal skin beneath which the meconium filled rectal pouch may be seen (Fig. 5) Simple incision and dilatation of the anal canal adequately relieves this type However when the defect involves the rectum, the problem is more complicated If the rectal defect measures less than 6 cm ($2^2/_3$ inches) a perineal approach may be used After identifying the external



FIG. 5 Imperforate anus, blocked only by persistent anal skin.

anal sphincter the blind end of the rectum is identified mobilized and sutured to the anal sphincter Since a rectovesical rectourethral, or rectovaginal fistula may be anticipated in more than half of these cases the identification of such a communication should be sought. Failure of the rectal pouch to mobilize anteriorly is evidence of such a communication. If the fistula is identified, it should be divided and both the urinary or vaginal and the rectal defects carefully closed. A rectal defect measuring more than 6 cm. (2 ½ inches) requires the establishment of a colostomy deferring reconstruction until the child is several years of age

Congenital stenosis of the gastrointestinal tract results embryologically from incomplete canalization thereby causing an area of narrowing of varying degree More often than not, the obstruction will be complete, causing symptoms indistinguishable from congenital atresia. The same sites of predilection as atresia, namely the duodenum ileum, and anus, are encountered Although the symptoms of congenital stenosis appear in the early weeks of life in most cases the lumen of the stenotic area may be of sufficient caliber to permit relatively normal gastrointestinal activity for months or years In these cases Farber s test usually reveals the presence of aspirated vernix cells Emergency surgical intervention is frequently required and resection with primary anastomosis is the procedure of choice Attempts at dilatation of the stenotic area are seldom successful *Anal stenosis* usually responds to repeated dilatations over a period of several years Incision of the stenotic anal canal is seldom required.

Meconium ileus clinically indistinguishable from congenital atresia of the ileum results from failure of the digestive enzymes to liquefy the meconium properly The inspissated meconium obstructs the lower bowel, usually the terminal ileum The diagnosis, usually made at the time of operation for suspected congenital atresia, is evidenced by the finding of inspissated and obstructing material in a distal, nonatretic loop of bowel (Fig 6) Repeated irrigations and aspirations of saline through a catheter purse-stringed into the obstructed loop will finally permit liquefication and removal of the tena

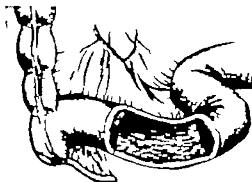


FIG. 6. Meconium ileus. Inspissated and obstructing material in a distal, nonatretic loop of bowel. Clinically indistinguishable from congenital atresia of the ileum.

cious meconium. After instilling 30 to 50 cc. of dilute trypsin solution into the bowel the catheter is withdrawn and the purse string suture tied Inasmuch as the basic disorder in meconium ileus is one involving inadequate tryptic activity of the pancreatic juice oral administration of commercially available pancreatin or trypsin is indicated. In two fatal cases of the authors, fibrocystic disease of the pancreas was demonstrated at autopsy A third case survived operation.

Volvulus of the bowel due to malrotation occurs principally in the first weeks of life, but may occur any time during infancy Abnormal rotation or failure of rotation of the midgut with subhepatic arrest of the cecum results in intestinal obstruction either by twisting of the bowel on its abnormally narrow mesentery or by compression of the distal duodenum by the abnormally rotated cecum (Fig. 7) Prompt surgical relief of the volvulus and obstruction is essential. Familiarity with this embryologic abnormality permits its recognition at the time of surgery and ready reduction by division of the abnormal peritoneal bands

Infancy During the first two years of life exclusive of the first few weeks, the important abdominal emergencies requiring surgical intervention are congenital pyloric stenosis, intussusception and incarcerated and/or strangulated hernia.

Congenital pyloric stenosis results from hypertrophy of the circular muscle guarding the outlet of the stomach and causes the characteristic clinical picture of projectile vomiting, weight loss alkalosis, and visible peristaltic waves The onset of symptoms occurs usually in the second or third week of life and the diagnosis is usually established at the fourth to sixth week by palpation of an olive-sized mass in the right epigastrium. Although the urgency of operation in these cases should never preclude adequate preoperative preparation unnecessary delay may increase the eventual operative risk. The use of a transverse right upper abdominal incision with lateral retraction of the right rectus muscle permits adequate exposure of the pyloric tumor and minimizes the possibility of wound dehiscence a complica



Fig 7 Volvulus.

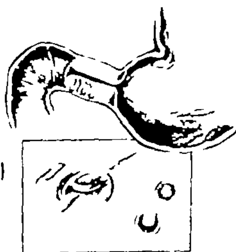


Fig 8 Fredet Ramstedt pyloroplasty

tion that occurred in five per cent of our cases in which a vertical incision was used. The Fredet Ramstedt pyloroplasty consisting of division of the circular muscle of the pylorus, affords prompt and complete relief of the obstruction (Fig 8) The technical hazard of perforation of the duodenal mucosa in this procedure may be avoided by extreme care in the division of the most distal fibers of the circular muscle The installation of a small amount of methylene blue into the stomach prior to surgery is recommended, inasmuch as a minute perforation of the duodenal mucosa, which if overlooked may be fatal leads to conspicuous discoloration at the site of perforation

Intussusception[1-] occurs at an average age of thirteen months usually in healthy robust male infants The ileocolic type of intussusception is the commonest (Fig. 9) The clinical picture

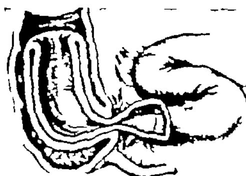
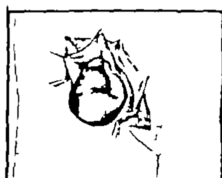


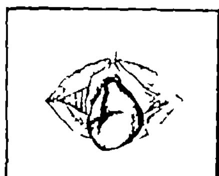
FIG. 9 Intussusception ileocolic type.

is characterized by paroxysms of acute abdominal colic between which the infant appears comfortable Vomiting and the passage of blood stained or "currant jelly" stools occur after a variable interval An abdominal mass is palpable in approximately twenty five per cent of cases The appearance of fever or leukocytosis is an indication that the intussuscepted bowel may be irreparably damaged The mortality is directly proportional to the duration of the condition Therefore early recognition and prompt reduction of the intussusception is all-important. After the condition has persisted for twelve to twenty four hours the intussusception may progress even as far as the rectum

Nonoperative reduction of the intussuspection by means of air insufflation of the colon or by the use of a barium enema has been employed by some However the possibility of effecting a reduction of bowel that has become seriously damaged, and the time lost in those cases in which reduction is unsuccessful by these nonsurgical means has discouraged the common adoption of these procedures Operative management is usually employed, consisting of reduction of the intussusception by gentle manipulation in an orad direction. In those cases in which the viability of the intussuscepted bowel is in question after its reduction return of the normal color after wrapping the bowel in warm tapes for five to ten minutes, the appearance of peristalsis and identification of pulsation in the mesenteric vessels are indicative of the bowel viability Irreducibility of the intussuscepted bowel or other irreparable damage requires either exteriorization or resection with primary anastomosis The latter procedure is preferable and is tolerated by these infants if they are properly supported during the operation by the liberal use of blood and properly controlled anesthesia.

Incarcerated and/or strangulated hernia occurs more commonly during infancy than in the newborn or in childhood. Operative relief in all but those cases in which early reduction is easily effected is required. Although the majority are inguinal, incarceration or







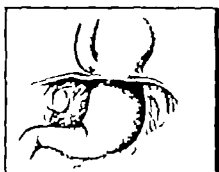


FIG. 10 Incarcerated and strangulated hernias.

strangulation may occur in umbilical diaphragmatic femoral or internal hernias (Fig. 10)

(a) *Inguinal hernia* in the infant is almost without exception of the indirect type Incarceration or strangulation occasionally occurs in a hernia that had previously been easily reducible Irritability painful crying refusal to eat and vomiting in an infant with a protruding hernia point to this complication The decision to operate should be made promptly if manipulation does not readily reduce the hernia

Although reduction may occur during the administration of the anesthetic the operative procedure should be pursued inasmuch as the reduced bowel may have become gangrenous After opening the hernial sac and determining the viability of the strangulated or incarcerated bowel, simple excision of the sac supplemented by the insertion of several sutures to reduce the size of the internal inguinal ring if it is dilated is an adequate operation Irreparable damage to the strangulated bowel requires resection and anastomosis

(b) *Diaphragmatic hernia* may at times assume emergency proportions in the newborn or infant. Inasmuch as the common site of such hernias is through the foramen of Bochdalek most of these congenital hernias have no sac and a large amount of intra abdominal contents may reside in the left thorax, causing considerable respiratory and cardiac embarrassment Operative reduction of

the hernia should be carried out promptly upon its recognition in either the newborn or infant. The transabdominal approach is preferred to the transthoracic inasmuch as the abdominal organs are easily reduced from the thorax and the defect of the diaphragm is easily repaired. If it is evident that closure of the abdominal wall will result in a marked increase in intraperitoneal pressure, the closure should be limited to the skin and subcutaneous fascia with subsequent repair of the ventral hernia.

(c) *Umbilical hernia* only rarely becomes incarcerated or strangulated. However, when this catastrophe does occur, prompt surgical relief with subsequent repair of the hernia is indicated.

(d) *Femoral hernia* is extremely rare at this age. However, when present it has the same potentialities as inguinal hernia with respect to incarceration and/or strangulation.

(e) *Internal hernia* is relatively rare. The signs and symptoms point to intestinal obstruction, and the true cause is identified usually at the time of operation. Reduction of the hernia with repair of the defect should be carried out.

Childhood. Conditions requiring emergency surgery in this period of life are limited chiefly to appendicitis and trauma of abdominal viscera.

Appendicitis remains the commonest surgical emergency in pediatrics. Prompt diagnosis of this acute abdominal disorder and early operative treatment have greatly reduced the morbidity and mortality of this condition. Abdominal pain, nausea and/or vomiting, or anorexia in an otherwise healthy child is the common mode of onset. Little or no fever may be present, but the child appears listless, irritable, and prefers to rest, often lying on the right side with the thigh flexed. Localization of abdominal tenderness to the right lower quadrant is the most significant diagnostic sign. The interval between onset and such localization of tenderness is variable from a few hours to several days. Frequently the course is rapidly progressive, and evidence of peritoneal irritation develops in six to eight hours. The demonstration on rectal examination of localized tenderness on the right is frequently of diagnostic significance. Unfortunately, the clinical picture is often obscured by the absence of any of the so-called "characteristic" signs or symptoms.

Acute nonspecific mesenteric adenitis[6], which closely simulates acute appendicitis, is most important in the differential diagnosis. The former condition is, however, characterized by an onset during or following a minor respiratory infection, more diffuse abdominal pain, and less acute systemic manifestations. The authors have observed a palpable spleen in about forty per cent of cases of mesenteric adenitis. Because a clear-cut differentiation usually cannot be made, operation is advisable lest an acute appendicitis be allowed to progress; also, for reasons which are not obvious, most of these children are relieved of recurrent abdominal pain after appendectomy. It is also important to consider in the differential diagnosis several medical conditions which may simulate appendicitis and in which surgery is definitely contraindicated, notably *pneumonia*, pyelitis, rheumatic fever, diabetic acidosis, sickle-cell crisis, and typhoid fever. Careful examination should always be done and special studies made if doubt exists, for a fatal outcome may follow surgery in the presence of one of these nonsurgical conditions.

When the diagnosis of appendicitis is made operation should be carried out without delay The appendix may occupy a variety of positions with reference to the cecum and commonly is situated retrocecally Acute inflammation which has progressed to suppuration results in fibrinous adhesions about the appendix and renders its removal more difficult. Retrograde removal of the appendix should be done if it facilitates the operation Only rarely is it necessary to abandon appendectomy and simply drain the wound, but this should be done if the operation is prolonged and associated with undue trauma to the cecum and adjacent ileum

When the appendix has perforated, a localized abscess may form or generalized peritonitis ensue Frank abscess formation is best treated by generous antibiotic therapy with deferred drainage of those collections that fail to resolve In spreading peritonitis it is desirable to remove the appendix if this is not technically difficult or will not result in further spread of infection In the presence of a suppurative or gangrenous appendix drainage of the wound is advisable A rubber drain placed down to the peritoneum will minimize wound infection consequent upon inevitable contamination Drainage of the peritoneal cavity however is rarely indicated except in the presence of an abscess

TRAUMA OF ABDOMINAL VISCERA During this period of increased activity the incidenc of traumatic injuries requiring surgical relief is great. In children the commonest injuries of abdominal viscera necessitating surgery are those involving the spleen liver kidneys, and the rectum Seemingly minor trauma often associated with no immediate evidence of injury may in the course of a few hours develop into a surgical emergency Close observation following trauma, particularly when intra abdominal injury is suspected, is recommended to insure prompt diagnosis and early operation in such cases.

Injury to the *spleen* usually due to nonpenetrating trauma of the left lower thorax or upper abdomen, is incurred frequently and delayed shock due to hemorrhage is common. If injury to the spleen is suspected the child should be hospitalized and a careful record of pulse rate, blood pressure and hematocrit recorded. Sufficient whole blood should be available and provisions made for immediate operation if evidence of internal hemorrhage develops Often several hours or one to two days will elapse between the time of injury and the appearance of signs of acute hemorrhage A subcapsular hematoma may rupture several days after the injury resulting in acute hemorrhagic shock Splenectomy is indicated inasmuch as the degree of damage to the spleen precludes repair At operation initial ligation of the splenic pedicle prevents further blood loss and renders removal of the spleen easier

Injury to the *liver* less commonly requires surgery for hemorrhage is usually less acute Continued bleeding evidenced clinically by an elevated pulse rate moderately lowered blood pressure and slowly falling hematocrit calls for prompt surgical intervention Repair of the laceration with loosely tied mattress sutures of catgut or the application of gelfoam or other topical agent over the area usually controls the bleeding However if the trauma is severe and hemorrhage marked the use of plain gauze packing, brought out through a stab wound may be required

Injury to the *kidneys* not infrequently

requires surgical intervention. Hematuria following injury directs attention to the urinary tract, and persistence or clearing of the hematuria are valuable prognostic signs Cystoscopy and ureteral catheterization may be indicated to localize the site of bleeding Surgical exploration of the kidney should be done when hematuria persists or increases or when clinical signs indicate that hemorrhage is significantly great. Nephrectomy is not always necessary for minor injuries may be repaired by suturing Nephrectomy should never be done until a pyelogram demonstrates a functioning kidney on the opposite side. Less severe damage to the kidney may result in the development of a perirenal hematoma. If this enlarges progressively or rapidly it should be evacuated. Infection is prone to develop after renal injuries with subsequent abscess formation These purulent collections require surgical drainage

Penetration of the rectum usually the result of a fall onto a sharp object, may require laparotomy to repair the perforation and effect drainage However proctoscopic examination may reveal that the site of perforation is well below the peritoneum in which case laparotomy may be deferred If the perforation cannot be visualized and abdominal signs of intestinal perforation develop laparotomy is indicated The perforation is closed and the wound drained Vigorous antibiotic therapy should be used

Perforations of the stomach and small and large bowel are uncommon in children. They more commonly result from sharp objects which are ingested, *e g* open safety pins If such an accident is suspected, laparotomy with thorough inspection of the entire intestinal tract and repair of the perforation is indicated

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greatest vasodilation of the affected extremity will be obtained by simple bed rest and cotton encasement of the limb However the use of vasodilating drugs is indicated as a possible beneficial adjunct. The list of these drugs increases almost daily The simple nitrites apparently have little if any effect Papaverine given intravenously the first twenty four hours of the attack may have some beneficial effect, and should be used without hesitation. Acetylcholine was introduced many years ago with great enthusiasm but soon proved to be ineffective because of its rapid decomposition in the tissues Since that time a variety of more stable and more effective preparations has been introduced chief among these being priscoline, roniacol, tetraethylammonium chloride and related compounds and more recently peritrate a derivative of erythroltetranitrite and hydergine, a hydrogenated form of ergot. In using any of these drugs in the treatment of acute closure of a large artery one must realize the limitations of their action and must not place too much reliance upon them as a sole agent in relieving vascular spasm Priscoline may be given orally or parenterally or both realizing that severe hypotension may occur as one of the side effects of its action Roniacol may be administered in the same way but does not produce as much hypotension although nausea and vomiting may occasionally occur Tetraethylammonium chloride is a powerful vasodilator but also produces alarming hypotension in some cases and is therefore not entirely safe Peritrate is given orally and is safer than the others because of the slower and more prolonged action Hydergine is given orally and parenterally If one recognizes the limitations and dangers of these adrinergic compounds they may be administered with discretion as adjuncts in the treatment

Alcoholic beverages with a high alcoholic content, such as whiskey have given sufficient proof of their clinical value as vasodilators to be extremely valuable not only for their warmth-producing effect in the legs, but also for their effectiveness as analgesics In my experience a combination of whiskey and aspirin has proved more effective in relieving pain in these cases than almost any other measure Whiskey is prescribed in doses of 30 cc (1 ounce) three or four times a day

Pain is frequently but not always, a difficult problem In those cases where a good outcome is to be expected, pain may subside within a few hours after the above routine is instituted and there may be no necessity for the use of narcotics. However where the obstruction has been extensive and complete and where gangrene of greater or less degree will eventually develop the pain is severe and becomes more so with the onset of gangrene Here the unlimited use of narcotics is justified

As soon as the diagnosis is made and the patient is admitted to the hospital, anticoagulant therapy should be instituted not for the purpose of relieving the obstruction but to prevent propagation of the clot and the possible throwing off of emboli Anticoagulant therapy may also prevent the development of venous thromboses in the ischemic parts thus minimizing the chances of fatal pulmonary emboli Almost every physician has his favorite method of using anticoagulants and should employ those with which he is most familiar and with which he has had the best results I favor heparin particularly the delayed action preparation because of its rapid action simpler administration without

the necessity of frequent prothrombin determinations and its greater safety particularly where later amputation may be required. However there are many advocates of dicumarol in whose hands equally good results have been obtained. In any event, some form of anticoagulant therapy should be employed until the patient is up and around.

In my experience, paravertebral block and lumbar sympathectomy are of limited value in these acute conditions. Although again in the hands of others equally good, but not superior results appear to be obtained. There is no doubt but that paravertebral blocks and lumbar sympathectomies relieve whatever vasospasm is present and the beneficial effect of this vasomotor release is obvious However too much reliance should not be placed upon these methods, particularly when the patient's general condition is not of the best. By following the simple procedures outlined above without a block or sympathectomy a satisfied outcome may be expected in a large percentage of cases.

If the obstruction is incomplete and the vasospastic phenomena are relieved by the above described measures pain disappears the toes become warmer and of better color and after a period of about three weeks in bed the coverings may be removed and the patient may be allowed to walk about.

Where the obstruction to the circulation has been so severe and extensive as to prevent all possibility of continued life of the affected portion of the limb conservative measures of any kind or combination will prove of no avail and gangrene will develop The extent of the gangrenous process determines the level of amputation, if such is decided upon In any event, it is wise to wait patiently until the ultimate limit of gangrene is reached Where toes alone are involved, extreme conservatism is indicated because in these cases spontaneous amputation of digits may be expected, with a good functioning extremity as the reward. The treatment of this type of occlusive gangrene is founded upon logical premises Complete bed rest, retention of the natural warmth of the extremities by complete covering of the limb with cotton, vasodilating drugs and a large measure of patience soon result in a well defined line of demarcation When this is established, pain disappears for the most part spontaneously and the patient's general health improves

Local treatment of the gangrene at this point is important and requires meticulous attention to detail. Daily foot soaks of warm soap and water are instituted for twenty minute periods A dressing of boric acid ointment is next applied to macerate the dead tissue and bring into view more clearly the line of separation between living and dead tissue The soaks and boric acid ointment dressings are repeated daily and when a sufficiently clear line of demarcation begins to appear removal of the affected toe or toes may be facilitated by careful dissection along the line of demarcation, avoiding trauma to living tissue Within a few weeks, or sooner it will be found that the affected digits may either be disarticulated with ease or in some instances a bone cutting forceps may be necessary to sever the phalanges along the shaft of these bones In most cases disarticulation through the interphalangeal joints is the easiest procedure. In these cases it will be found after a few days that the joint cartilage of the proximal living phalanx can be lifted off easily with a small instrument, leaving a rough bony surface which soon

covers itself with healthy granulations From this point on epithelization takes place rapidly and the entire process takes about two or three months for complete healing

Spontaneous healing of occlusive gangrene can occur at higher levels such as the tarsometatarsal joints or rarely through the tarsal bones These cases, of course are more difficult and require longer periods of time for healing

Where the weight bearing portion of the foot is destroyed, by the gangrenous process a major amputation is obligatory Two types of operation may be considered at this time The safest and simplest entailing the least shock and the lowest mortality is the supracondylar amputation above the knee In those cases where the femoral pulsation can not be felt, sufficient collateral circulation may be present at the level of operation providing ample time has elapsed between the original occlusion and the day of operation In other words the longer one waits apparently the more time is allowed for the development of collateral circulation in the thigh Intravenous anesthesia is preferred to spinal or to general anesthesia It may be combined with nitrous oxide gas, cyclopropane or other mild general anesthetics Careful preparation of the thigh and leg is essential and should consist of a preoperative scrub of the operative area with benzine followed by alcohol in addition to the usual preparation the day before the operation No tourniquet should be used as all bleeding is easily controlled and excellent hemostasis may be secured without a tourniquet A circular incision is made just above the upper border of the patella The incision is carried down to the bone using an ordinary scalpel instead of a large amputation knife Careful hemostasis is essential The sciatic nerve is cut in the same plane and is not manipulated. The proximal end is allowed to retract normally I have found it unnecessary to inject alcohol or other drugs into the nerve as this entails additional trauma

The soft parts are now retracted proximally for about 5 cm (2 inches) and the bone is sawed at this level Prior to sawing the periosteum is cut and scraped distally After the bone is severed the muscles fall together naturally over the cut end and should be sutured lightly to cover the exposed end of the bone The fascia is now closed and the skin brought together with interrupted silk sutures Careful approximation of the skin edges is essential and no drainage of any kind is necessary

Providing there are no contraindications the patient is allowed out of bed the day following operation and may remain in a wheelchair daily thereafter The use of crutches may be allowed as early as the third day if the patient's general health warrants Sutures are removed on the sixth or seventh day and the patient is then allowed to go home. An artificial limb may be worn within three weeks following operation.

The mortality from this simple operation is extremely low in my hands it is about five per cent

Where it is felt that the circulation below the knee is adequate a leg amputation about 15 cm (6 inches) below the lower border of the patella may be attempted It must be remembered however that this is a more difficult and time consuming operation and is consequently attended with a greater degree of operative shock. A circular incision is made through the skin and soft parts about 15 cm (6 inches) below the lower border of the patella A longi

tudinal incision is now made at right angles to the circular incision directly over the fibula for a distance of about 7.5 cm. (3 inches) proximally Through this incision, about 5 cm. (2 inches) of the fibula are removed using either a rib cutter or a bone cutting forceps The soft parts are now cut in one plane as in the supracondylar operation Careful hemostasis is essential. The soft parts are now retracted above the level of the skin incision and the tibia is sawed through at this level After the periosteum has been cut, and scraped distally the muscles are allowed to cover the exposed end of the tibia and are held together lightly with sutures The skin edges are now approximated carefully with silk and a light dressing is applied. In both of these operations the use of silk or cotton throughout is preferred to catgut. The patient is allowed out of bed the day after operation and is encouraged to use crutches as soon thereafter as possible

Infections of the Lower Extremities

Because of the usual arterial insufficiency in the lower extremities of diabetic patients, they are more prone to infections than normal individuals The serious nature of these infections comprises not only the immediate danger but also the chief sequela of gangrene, which may lead to disastrous consequences For this reason much more attention must be paid to the element of infection in diabetic patients than heretofore It is unfortunate that all attention appears to be directed to the insufficient circulation in these extremities with attendant neglect of the underlying and more important factor of infection It is only when this phase of diabetic gangrene in its incipient and progressing stages is thoroughly understood that the number of amputations for diabetic gangrene will decrease and the mortality of this disease be lessened Mycotic infections of the feet are extremely common In normal individuals fungi of various kinds may be present as harmless saprophytes in limbs with deficient circulation Particularly in diabetic patients these organisms may become unusually active and may be the starting point of serious secondary pyogenic infections

The usual sites of these infections are in the order of their frequency the interdigital spaces plantar calluses corns, and fissures on the heel. In the interdigital spaces the first intimation of mycotic activity is an itch or burning sensation between the toes At times this is accompanied by redness of the interdigital spaces and surrounding areas In the diabetic patient, this condition calls for immediate action which should consist of daily foot soaks of soap and water followed by the application of a fungicidal dusting powder Of these mention may be made of asterol desenex, and other similar fatty acid salts A convenient form of fungicidal therapy is mycoderm soap which may be used in a foot bath.

If the infection here described has been neglected, a crack will soon form in the interdigital spaces allowing the entrance of pyogenic organisms. These will set up a localized cellulitis which will manifest itself as a painful reddened area between the toes extending to the dorsum of the foot and to the adjacent toes. At this stage, a real emergency has arisen which requires immediate and intensive treatment. Complete bed rest is essential The interdigital space involved is irrigated with peroxide of hydrogen followed by irri

gation with ether to remove all fatty debris The open crack is packed with gauze saturated with azochloramid in triacetin in the stock solution strength of 1 to 500 Antibiotics are administered immediately Terramycin is preferred

If the initial infection occurs in a plantar callus or a corn on the fifth toe in addition to the treatment outlined, careful removal of overlying calloused tissue must be done immediately thus exposing the central core of the infection Any areas covered by this calloused material will harbor more infection and will eventually allow spreading of the underlying infection. Hence complete removal of all dead epithelium is essential Infection arising in a fissure on the heel has the same pathogenesis As soon as the crack becomes painful and tender immediate action must be taken If the underlying dead epithelium is raised carefully with a forceps and is gently removed with a sharp scissors it will be found that a small circular black ulcer is underneath the overlying dead skin This area should be carefully irrigated with peroxide followed by ether and a gauze dressing of azochloramid applied as in the interdigital infections. Complete bed rest at this stage is essential and antibiotics are administered

Careful and meticulous attention to these apparently harmless infections will be rewarded with a lower incidence of secondary gangrene If however infection has gone beyond the point described above immediate and thorough surgery is indicated In the interdigital infections there may be abscess formation along the plantar tendon sheaths or on the dorsum of the foot These areas are readily detected by pressure upon the tender area watching at the same time the original break in the interdigital skin If pus is present in the suspected area pressure upon this point will cause it to appear in the original break in the skin. There may be a concomitant rise in temperature and other constitutional signs of infection. In the diabetic patient, a sudden change in insulin requirement may be seen In some patients who before the onset of infection were never cognizant of glycosuria, there may suddenly appear every sign of diabetes. In severe infections insulin may be completely ineffective until the infection is under control. When the diagnosis of pus in the foot has been established, immediate and adequate incision and drainage are indicated. If the abscess is found on the dorsum of the foot, adequate incision again must be made exposing all hidden pus pockets Since the feet of diabetic patients with arteriosclerosis usually are hyposensitive incisions may in some cases be made without anesthesia Where an extensive operation is necessary however general anesthesia may be used. In no case should local infiltration or freezing anesthesia be employed since local gangrene will follow

After the pus pockets are completely exposed the resulting cavity is irrigated with hydrogen peroxide and is then packed firmly with gauze saturated with azochloramid in triacetin Antibiotics are administered and the patient is confined to complete bed rest Ambulatory treatment of these infections is unsuccessful and may be dangerous In rare instances, infections of the feet in diabetic patients do not respond to the most meticulous care with resulting progression to gangrene of various parts of the foot depending on the relation of the adjacent arteries to the infected area In the case of interdigital infection thrombosis of the digital arteries is soon

followed by gangrene of the two adjacent toes On the dorsum of the foot, gangrene of a large portion of the dorsal tissues may result. In the case of a plantar tendon sheath infection, gangrene of two or more toes plus gangrene of a large area of plantar tissue may be the result of uncontrolled infection. On the heel, a large circular area may develop with extension of gangrene radially to the os calcis The latter condition is extremely painful and difficult to treat.



FIG. 1 Extensive diabetic gangrene with oscillometric reading of 1 at the ankle level.

When it seems almost impossible to control infection in various parts of the lower extremities in the diabetic patient, the question naturally arises whether or not one should amputate the entire limb It must be emphasized that such a decision should not be made hastily The day of the emergency operation in diabetic gangrene with infection is past. With the introduction of antibiotics the danger of septicemia or of rapidly spreading gangrene with a fatal outcome is no longer the bugaboo frightening the surgeon into a hasty or ill-advised amputation

Progress in the field of angiology with particular reference to diabetic gangrene is reaching the point where a decision to perform a major amputation of an extremity must rest upon fairly accurate objective findings rather than upon hasty clinical judgment based upon fear and traditional misconceptions One of the most important factors in the decision of whether or not to amputate is the status of the arterial circulation in the affected extremity While clinical examination of the limb is of some value, its color and temperature do not give



FIG. 2. Same case as Fig. 1 Six months later with spontaneous amputation of gangrenous tissue and stump almost healed.

WILLIAM E. BRANCH M D

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Emergent Surgery in the Aged

EMERGENT surgery constitutes one of the most dramatic aspects of the practice of medicine In the aged, because of the high morbidity and mortality such procedures demand all the skill and resources of the performer The mortality reported by Haug and Dale[1] comparable to that in our experience probably strikes an average Their rates were 21 9 per cent in emergent surgery as contrasted to 5 7 per cent in elective surgery The physician who is faced with the problem of an elderly patient whose condition demands emergent surgical treatment, therefore, should attempt to convert that situation to one for which an elective procedure may be safely considered

The principles of emergent surgical treatment for elderly patients are the same as for younger persons Several factors assume prime importance in the aged Because of the increased incidence of complications, a decision is required as to the immediate problem as well as to the need for definitive treatment

Despite his lowered functional reserve the patient who has reached the last years of life is a good risk for elective surgery He exemplifies the "survival of the fittest" he has a tenacity for life Immunity to the common destructive forces has developed. His heredity his endocrine function his previous fortunate escape from the carcinogens and his psychologic outlook have contributed to his survival and are factors in evaluation of his fitness for surgical treatment of comparable importance to the measurable physiologic processes.

The increase in mortality in emergent surgery in the aged is due mainly to shock disturbance of fluid balance and pulmonary atelectasis (the "pneumonia" of bygone days)

The problem of an elderly patient requiring immediate surgical intervention demands first, rapid evaluation of the patient both psychologically and physically and second, if possible delay of surgical treatment until shock dehydration or abnormalities of electrolyte balance if present, can be corrected

Surgical treatment no longer consists in a single individual effort but rather in teamwork. The internist the anesthetist, the surgical team and the trained nursing personnel collaborate in the patient's management from first to last, through his evaluation, preoperative preparation surgical course, postoperative care, and convalescent regime While the patient is examined, assurance and encouragement should be given him

by every member of the team Most elderly patients previously have experienced surgical treatment, but rarely an emergent procedure. They usually have the will to live and, therefore can be easily rallied into a courageous psychologic state

Sedation should be light, as the elderly are more subject to cardiac and respiratory depression than are younger persons to compensate fortunately they are more tolerant of pain.

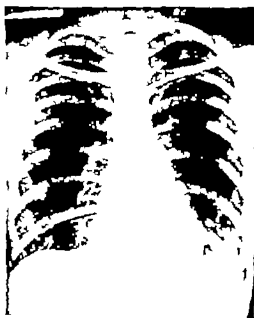
The cardiovascular system should be rapidly evaluated the liver palpated, the general physical condition observed, and routine laboratory studies done An irreversible state of shock may be due to hepatic failure. A history of some type of biliary infection exists in twenty five per cent of the aged therefore the incidence of cirrhosis and hepatitis will be high in this group Such patients are poor surgical risks

The status of renal function is of paramount importance to geriatric surgery It may often decide whether or not surgical intervention of any nature will be tolerated, or whether definitive surgical measures can be carried out. Renal function and urologic status may be estimated on the basis of the history the physical observations, and the blood nonprotein nitrogen—often simply by the specific gravity of the urine

Measures to correct abnormalities of fluid balance must be predicated on several factors common to patients of advanced years after the age of sixty renal function declines progressively because of the diminished concentrating ability of the kidney Arteriosclerosis is present to varied degree The majority of elderly persons have had repeated attacks of bronchial infection the respiratory and vascular systems, therefore, must be considered in balancing the



A



B

FIG. 1 Atelectasis of left lower lobe with mediastinum shifted to left. Note air under right diaphragm. Second postoperative day B—Same case with bronchoscopic removal of mucous plug.

fluids. There is susceptibility to large amounts of sodium leading to rapid development of edema and in many cases pulmonary engorgement. Most observers feel that 5 Gm (75 grains) of sodium per twenty-four hours is an optimal amount unless there is definite loss of sodium In most instances 1000 to 1500 cc. (2 to 3 pints) of a five per cent solution of glucose in water will suffice to restore the fluid balance in such patients

Some form of malnutrition some degree of anemia and diminished blood volume are commonly observed so that blood transfusions are essential The availability of blood and the antibiotics has lent us courage in surgical treatment of aged patients but adequate attention preoperatively to hematic deficiencies is essential

In some instances a situation that, in the past, would have indicated emergent surgical treatment can today be converted into one permitting an elective procedure Recently a seventy year-old woman with a temperature of 104 F (40 C) rapid pulse, and a leukocyte count of 24 000 with eighty-eight per cent polymorphonuclear leukocytes was admitted to the hospital She had a large mass in the left lower quadrant, obviously an abscess and a vesicocolic fistula with excretion of fecal material in the urine her abdomen was distended and rigid. The erythrocyte count was 3 070 000 with 9 Gm hemoglobin Rather than opening and draining this abscess immediately it was felt advisable to correct the patient's fluid balance and to give her transfusions of blood and large doses of antibiotics A weighted small tube was passed Within twelve hours deflation was accomplished and her condition improved to such an extent that we prolonged observation The feedings were continued despite the presence of the tube electrolyte and blood balances were corrected At the end of one week both leukocyte and erythrocyte counts were normal The mass in the left lower quadrant had disappeared and the abdomen was soft. The patient was taken to surgery A carcinoma of the sigmoid had ulcerated and attached itself to the bladder producing the fistulous tract. The abscess had completely disappeared. We were able to remove two-thirds of the bladder and do an end to-end *anastomosis of the sigmoid* The patient made an uneventful recovery

In some instances of course passage of an intestinal tube in the presence of an intestinal obstruction masks the symptoms of complete obstruction In others, however if the case has been properly evaluated, it cannot only be a safe but also a life-saving procedure.

In the patient described the tube had by passed the partial obstruction in the small bowel caused by attachment of the intestine to the inflammatory portion of the abscess the end of the tube was found at the ileocecal junction Had surgical intervention been attempted earlier so extensive a procedure would have been impossible in one stage had drainage of the abscess been done initially return into the abdomen would have been a much more difficult procedure and would have increased the risk

Conversely cases are encountered in which their emergent nature does not permit temporization We had a patient with a gastrointestinal hemorrhage who was passing a large amount of blood by rectum Transfusion of blood was instituted but the patient passed blood faster than single transfusions could be given he was taken to surgery while multiple transfusions were administered under pressure The abdomen was opened The

entire bowel large and small was found to be filled with blood up to about 46 cm of the terminal duodenum in this area a small nodule about 4 mm. was palpated. The bowel was opened a small leiomyoma with a necrotic center and arterial bleeding was quickly removed the base sutured together and the gut closed Almost immediately the patient's blood pressure increased and, before he left the table he was in better condition than when the operation was started

Conditions affecting the head and the neck that require emergent surgical care rarely arise except in cases of injury due to accident. Acute parotiditis had a high morbidity and mortality in the past now it responds rapidly to antibiotics

Thoracocentesis usually suffices to tide the elderly patient with critical disease or injury of the chest over the emergent phase Emergent surgery of the chest is to a great extent, limited to accidental injury to the lung and/or its supporting cage The most frequently encountered emergency requiring imperative thoracic surgical intervention is that involving a crushing injury to the chest. Stabilization of the thoracic wall by towel-clip suspension of the sternum and removal of blood or air from the pleural spaces usually will obviate emergent surgery Atelectasis as a complication of thoracic injury occurs more frequently in the aged, probably due to their increased susceptibility to or history of low grade chronic bronchitis or bronchiectasis as mentioned previously Vigorous measures to clear an airway in these cases as in other emergent surgical conditions in the elderly is of primary importance intercostal injection of procaine hydrochloride will relieve pain and thereby permit coughing up of mucus so clearing the air passage this frequently is a lifesaving maneuver

An acute abdominal condition usually forces the surgeon to take immediate action If uncontrolled gastric hemorrhage is present, determination of the origin and the cause of the bleeding is most difficult Varix, strangulated diaphragmatic hernia (with or without ulcer) gastric ulcer carcinoma, gastritis, and duodenal ulcer as well as the rarer conditions, must be considered The history the physical examination and a plain roentgenogram of the chest and of the abdomen aid materially in arriving at a conclusion

A bleeding varix can be controlled by passing an esophageal tube and pulling the balloon tightly against the cardiac end of the stomach Gastrostomy (which will permit feeding the patient if essential) with gentle exploration, when needed, may be done under local anesthesia

Hemorrhage due to ulcer usually can be controlled by transfusion of blood, application of ice packs, gastric intubation with drip administration of a preparation of aluminum hydroxide and good medical management. Strangulated diaphragmatic hernia with ulcer often compels surgical intervention, preferably only vagotomy with pyloroplasty or gastroenterostomy but occasionally a cautious attempt may be made to close the diaphragmatic hiatus

In rupture of a hollow viscus, as gastric or duodenal ulcer we have returned to a minimal procedure that is closure of the perforation and deflation later if necessary we do a resection The morbidity and mortality is much lower in our experience, than by primary emergent resection

Acute cholecystitis may be controlled

Fig. 2.

by administration of antibiotics in most instances. In the presence of a gangrenous and ruptured gallbladder cholecystostomy is preferable to a complete exploration for determination of the patency of the common duct. If the latter is ascertained however a cholecystectomy can be done as rapidly as cholecystostomy and with almost as little shock and trauma.

Strangulated inguinal, abdominal and femoral hernias should be reduced, if possible and adequately prepared for later surgical repair If the hernia cannot be reduced surgical intervention is imperative

Acute appendicitis is not uncommon in the aged A difference of opinion exists as to drainage for rupture of the appendix. Some contend that only appendiceal abscess should be drained some are opposed to drainage for either abscess or general peritonitis Since the bacteria involved cannot be identified and since testing of bacteria *in vitro* is not dependable we are of the opinion that drainage again will be employed more generally and consequently the incidence of abscess formation and the mortality will be reduced "When in doubt drain" is a slogan not to be forgotten The method of choice of drain

age in pelvic abscess is through the cul-de-sac in the female and through the upper portion of the rectal wall in the male

There are many causes for intestinal obstruction in patients of the younger age group and even more in the elderly A plain roentgenogram will help to identify rupture of the gallbladder with large stone into the duodenum as the cause for obstruction of the small bowel and to recognize complete closure by carcinoma abscess, or adhesions it also aids differentiation of obstruction from ileus

Determination of the source of obstruction is of prime importance, inasmuch as passage of a long intestinal tube to effect deflation, as previously mentioned, sometimes masks the symptoms of complete obstruction However if the condition has been properly evaluated, a long tube with weighted tip may obviate the emergency It may be passed through the pylorus under fluoroscopy rapidly and accurately

Obstruction of the bowel due to a malignant tumor often necessitates colostomy the patient's fluid loss then may be corrected and his condition otherwise evaluated and managed in preparation for an elective procedure

Most uropathies of the aged either are not emergent or can be relatively easily converted to temporizable situations permitting adequate study preoperative preparation, and step-wise definitive care A truly emergent urologic disease rarely is encountered Trauma to a kidney a ureter the bladder or the urethra involving urinary extravasation or hemorrhage (especially renal) that cannot be controlled by conservative means requires emergent care In such event, renal function should be estimated by chemical studies of the blood and urography The emergent nature of extravasation of urine may be reversed by establishing thorough drainage of tissues thereby deferring definitive repair

Renal hemorrhage with declining hemoglobin and hematocrit, expanding accumulation of blood into the tissues or the urine and shock or impending shock generally cannot be converted to a non emergent status If the contralateral kidney is functioning well, nephrectomy may be considered Should the contralateral renal function be impaired repair of the bleeding kidney should be attempted

Obstruction to the flow of urine requires urgent management. If in the prostatic urethra catheterizations will permit temporization occasionally cystotomy is necessary Removal of the obstruction (stone, tumor prostatic tissue stricture etc.) may then be delayed until renal function and cardiovascular status are adequately stabilized.

Ureteral obstructions usually can be circumvented by indwelling ureteral catheters placed cystoscopically Nephrostomy which generally can be done with little more danger than cystotomy may be required as an emergent procedure Definitive surgical intervention then can be timed optimally

Few acute skeletal injuries of the aged necessitate bed rest. Continued ambulation wherever feasible is the aim today However the patients must be hospitalized immediately evaluated generally and medical management instituted promptly A steady reduction of mortality in fractures of the hip parallels the change-over from plaster casts and bed rest (thirty to seventy per cent) to the present day treatment by internal fixation and early ambulation (three to ten per cent)

Actual fixation of the fractured hip

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may be delayed twenty-four to thirty-six hours Emergency measures consist in skeletal traction by means of a Kirschner wire and suspension on a Thomas splint or a Braun frame Procaine infiltration around the fracture effects immediate relief of pain and permits traction Elastic bandages from toes to groin of both extremities will help to prevent phlebothrombosis Small blood transfusions and intravenous administration of the usual supportive fluids and nutritional supplements should be started Less than five per cent of patients may be in such severe initial shock as to forbid hip fixation Routine blood transfusions, even though little blood may be lost during the operation must be given because of the diminished blood volume known to exist in most aged persons Postoperatively the patient is placed in a wheelchair daily with minimal support of the injured extremity to prevent rotation

Compound fractures require even more careful debridement in the aged because of the lowered vitality of the subcutaneous connective tissues and the fasciae If gross contamination is not present, definitive treatment may be delayed ten to fifteen hours and antibiotics adequately administered thereby permitting general evaluation of the patient. A compound fracture of the shaft of a long bone of the lower extremity with gross displacement requires open operation moreover firm internal fixation obviates use of a cast and permits better mobilization

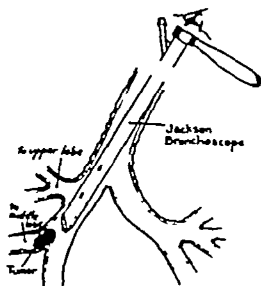
Present day anesthesia has progressed to the extent that any person who can be operated on may be put to sleep safely The selection of anesthesia in the elderly is important High spinal anesthesia is not as a rule advisable It paralyzes the arterial bed of the entire splanchnics as well as the lower extremities, which is approximately two-thirds of the vascular bed. Arteriosclerosis with lack of elasticity adds greatly to further shock that may be experienced by these patients We feel therefore that gas anesthesia is preferable personally we mostly use cyclopropane or nitrous oxide and oxygen inhalation anesthesia with a large proportion of oxygen, supplemented by pentothal sodium Adequate oxygen is most important in these arteriosclerotic patients they are more predisposed to hypoxia with subsequent brain deterioration. This is a most unhappy complication.

I recall Doctor Joslin's saying, years ago that he wondered at times "at the courage of the surgeon who dared to operate upon a diabetic of fifteen years duration, as they were riddled with arteriosclerosis " An aged patient with diabetes must be approached cautiously but, with good control of the diabetes they usually do well Postoperative hemorrhage is a dangerous complication, particularly in the elderly with their pipe-stem arteries Three rows of sutures are used in our gastric anastomoses—two in the small bowel and one row of cotton sutures in the large bowel.

In closing the abdominal wall each surgeon has a personal preference In the upper portion of the abdomen in the aged we employ 0 chromic sutures doubled to the peritoneum 0 chromic doubled to the fascia and both interrupted 00 cotton, subcutaneous plain 0 and dermal 00 to the skin The object of this method is to get these elderly patients up during the first or second postoperative day

Adequate deflation and nutrition following operation are most important For gastric procedures we introduced a small intranasal tube that is placed in the stomach before operation It con

sists of a very small plastic tube within a slightly larger plastic tube becoming a double-barrelled apparatus. The lower end of the outer tube is perforated. The terminal 15 to 20 cm of the inner tube emerges through one of the perforations of the outer tube at the level of the stomach and is placed through the enterostomy os or pylorus for feeding into the jejunum; the end of the perforated tube is placed in the stomach for suction and deflation. This apparatus is smaller and more comfortable than two single rubber tubes and permits the use of the other nostril for intratracheal intubation in patients with bronchial secretion.



Postoperative care must be governed by many of the points already mentioned, particularly by the amount of blood lost, the amount replaced and the patient's course during the last five minutes of anesthesia.

It is extremely important that the tracheobronchial system be thoroughly cleansed by suction before the patient leaves the operating table. Suction is much more important than is the "air way" through the mouth to the lung, and should be effected by catheterization or, if necessary, by bronchoscopy. In many instances we continue to employ the endotracheal tube until the patient responds vigorously. A plug of mucus may decide the outcome of the operation. In our experience most deaths have been due to unrecognized atelectasis. To combat this, our regimen consists not only in cleansing the tracheobronchial system but in employing endotracheal catheterization or bronchoscopy, if required, for several days. The

TRACHEAL ASPIRATION

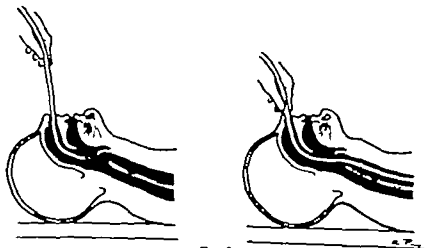


Fig. 3

patient is forced to cough while awake, to raise mucus He should be sitting up in the first two days and as soon as possible should be up in a chair and moving about.

The importance of avoiding overseda tion of these patients postoperatively cannot be overemphasized The first sedation should not be given until the patient is well out of the anesthesia and reacting vigorously The nurse is trained not to "kill these patients with kindness" by heavy sedation but to allow them to react, and to move when they complain of discomfort.

Feeding may be started on the first or second postoperative day beginning with a liquid, then changing to a soft and gradually to a full diet. Liquid and soft diet may be started even before removal of the intestinal tube Following gastric and intestinal surgery the tube is removed when peristalsis is established and results obtained from the enema usually in four to five days If the continuity of the bowel is in doubt, carmine red with mineral oil by mouth aids in determining whether or not the entire bowel is functioning

Balance of electrolyte is necessary The possibility of "water logging" the patient should be kept constantly in mind

Geriatrics as a separate limb in the ever-branching practice of medicine is a relatively green shoot. The surgeon con fronted by an aged patient in whom a surgical emergency exists must temper his intelligent curiosity in research in this comparatively new field with the surgical tenets of caution—yet courage.

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The assistance of Albert D Foster Jr., M D., anesthetist John B McDonald M D internist, Harold H Edelbrock M D urologist Paul H Harmon, M D., orthopedist, and Bert H Cotton, M D., thoracic surgeon, is gratefully acknowledged.

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Bites—Human and Animal

THE problem in surgery concerned with the treatment of wounds resulting from bites is principally one of the treatment of a contaminated wound It resolves itself into two major phases, the treatment of trauma incurred and the prevention or therapy of the infection which will or has resulted from the introduction of micro-organisms at the time of the infliction of the trauma These wounds have always been a great concern not only because of the damage done by the actual trauma to vital structures but there is an associated high incidence of infection in reported cases. Antibacterial therapy including the antibiotics and the sulfa drugs, have decreased the incidence and severity of these infections

Bites regardless of whether they are inflicted by humans or by domestic animals will have several features in common These include the making of a wound and the introduction of bacteria into vulnerable tissue spaces beneath the surface of the skin To these features which are common to all bites certain animals possess specific micro-organisms which will result in specific infections

Grossly the infections resulting from bites can be grouped into one of the following classifications

(a) A pyogenic type of infection or gangrenous cellulitis resulting from a single species of bacteria

(b) Infections resulting from a mixed bacterial flora consisting of either aerobic bacteria anaerobic bacteria or a combination of aerobic and anaerobic bacteria. In addition to the above bacteria, the wounds of bites are frequently contaminated with pathogenic spirochetes, fusiform bacilli organisms responsible for the actinomycotic type of infection, and members of the clostridia, including those of gas gangrene and tetanus

(c) This group is restricted to specific infections such as rabies rat bite fever and other specific types related to the specific animal inflicting the bite.

The treatment of the trauma of a bite will be that of any traumatic wound. This will include careful observance of all the aseptic and surgical technics required for clean wound healing Specific indications will vary with the location of the bite as well as with the structures injured However in all instances, care must be taken to repair the damage incurred so as to insure as little morbidity as possible Inasmuch as all these wounds are potentially contaminated with virulent and pathogenic bacteria, they will differ somewhat from

other simple traumatic injuries The question as to whether or not primary closure should be instituted has not been entirely settled However with the recent advances in antibacterial therapy in some instances it might be possible to obtain adequate approximation of the tissues with primary closure of the wound

HUMAN BITES

The problem of therapy in human bites is one of prevention of an infection or the treatment of an infection which has resulted from the injury Inasmuch as human bites are the result of a trauma inflicted during periods of high emotional activity the injured many times is unaware of the injury or at what time it was inflicted Therefore in a high percentage of these lesions medical attention other than first aid is not solicited until complications have occurred These injuries may also be so innocuous as to mislead the patient and physician into a false sense of security All penetrating wounds or lacerations resulting from trauma inflicted by teeth should be considered potentially serious

Human bites occur most frequently in the dorsum of the hand as a result of the closed fist striking the teeth of an opponent in a physical altercation However this is not the only location where these injuries have occurred, for they have resulted from a deliberate bite by an assailant on other parts of the body Regardless of the method by which a wound is incurred, the bacteria contaminating the wound will depend upon the bacteria in the mouth inflicting the wound, as well as the bacteria on the skin in the area in which the wound occurred Therapy of the infections resulting from human bites requires detailed knowledge of the tissue planes and anatomical structures involved The spread of the infection will depend to a great extent upon which tissue planes were contaminated at the time of the injury Mason and Koch[1] clearly demonstrated on cadavers the usual expected route of the spread of these infections when involving the hand However in certain specific instances, the nature of the infection may be of such fulminating characteristic as to disregard completely any limiting anatomical boundaries Therefore each of these types of cases presents its own individual problems

Experience has demonstrated that the resultant pathology of infections in wounds from human bites will be much more devastating than the initial trauma of the bite Primary closure of these wounds though highly desirable is usually a very unsafe procedure Surgical treatment requires the highest degree of judgment, in that, if the anatomical considerations are given the prime consideration in therapy it will be done at the risk of a possible resultant infection which may obliterate completely the anatomical triumph obtained

Bacteriological studies of infections resulting from human bites have demonstrated that these lesions are caused by a mixed flora composed of aerobic and anaerobic bacteria In addition to the usual aerobic bacteria of the mouth aerobic cocci members of the spirochete family and fusiform bacilli are frequently recovered from the discharges of these infections Less frequently blastomycetes, actinomycetes, *Treponema pallidum Clostridia welchii* and *Clostridia tetani* have been present Less frequently occurring pathogens often will cause a serious specific infection which may be superimposed upon an already existing necrotizing infection

Even though tetanus is a rare com

plication of a human bite antitetanus therapy is indicated and should be routine in all cases In the event that the infection is more specific particularly of the actinomycotic or blastomycotic type or any other specific type the etiology of the bacteria recovered will dictate the specific antibacterial therapy in that particular case

Treatment of Infections Resulting from Human Bites

The treatment will depend entirely upon the condition of the wound at the time the patient presents himself for therapy If this occurs immediately after the infliction of the wound the treatment should be that of a badly contaminated wound, directed toward the prophylaxis of an infection If however the patient does not present himself until after the infection is established the problem then no longer is one of the treatment of a human bite but of the infection resulting from it.

Prior to the recent advances in antibacterial therapy the nature of the infections and the limitations of the methods of combating or controlling infections often resulted in very mutilating lesions with loss of portions of the injured or wounded part. At that time careful surgical debridement with accurate hemostasis, antitetanic therapy and rest were about all that could be accomplished prophylactically The therapy of an infection which has established itself as a result of a human bite was essentially the same as the therapy for any other necrotizing type of infection. This would include incision and drainage when indicated rest of the injured part, and adequate and supportive therapy with compresses as indicated. (Also see Chapter 41)

Since the advent of the antibacterial drugs beginning with the sulfonamides and continuing to more recent antibiotics the entire conception of treatment of these lesions has changed The surgical considerations in the handling of these wounds at the time of infliction or shortly thereafter have not changed Even with the newer antibiotics it is still considered unsafe to close these wounds except in very unusual instances The prophylactic therapy will include judicial use of penicillin parenterally It will also include the administration of tetanus antitoxin prophylactically

The treatment of an established infection will not only require the best surgical judgment as to the indications for drainage and of carrying it out when indicated, but will also require the selection of the proper antibiotic. Studies by Boyce[2] and Longacre[3] have indicated that penicillin probably is the antibiotic of choice in the treatment of these infections. This does not necessarily mean that it is the antibiotic which will be most effective, but it is the antibiotic of choice because of its low toxicity rate as compared to its highly effective cure rate. Studies with bacitracin[4] have indicated that this antibiotic is equally as effective as penicillin in the treatment of these infections However due to the fact that parenteral administration of bacitracin is associated with a low incidence of a nephrotoxic reaction, the use of this antibiotic probably should be limited to the more severe infections, particularly those resistant to penicillin.

As with other infections the advent of specific antibacterial therapy has completely changed the clinical appearance and seriousness of these infections. They no longer present the dreaded problem which they formerly did but now with

proper therapy can be easily controlled with a resultant minimum destruction of tissue

Bites of Domestic Animals

The literature fails to give very much information which deals specifically with wounds resulting from bites of domestic animals With the exception of certain specific infections such as rabies rat bite fever and a few others little mention is made of infections with specific char acteristics resulting from these bites

The bite of an animal results in the infliction of a penetrating or lacerating wound with the introduction of pathogenic micro-organisms into vulnerable tissues In addition to the bacteria of the mouth of the animal inflicting the bite, the skin or clothing which the teeth of the animal must pass through before inflicting the bite will contain bacteria which also will be carried into the deeper tissues Therefore it is obvious that in the handling of these wounds all of the principles in the treatment of the badly contaminated laceration or wound particularly of the puncture type will apply These will include careful debridement of the tissues whenever possible maintenance of adequate hemostasis and the judicious use of prophylactic antibacterial therapy The question of primary closure is unsettled. It is often more desirable to leave these wounds open than to attempt a primary closure The secondary closure can be done at a later date

The treatment of an infection resulting from these bites will not differ from the treatment of an infection of any other wound The type of infection will depend entirely upon the etiologic bacteria which are present These bacteria will determine the choice of the antibiotic to be employed in the treatment and control of these infections Smears of the discharge from the wound at the time of the initial observation will often give valuable information which will assist in the choice of a suitable antibiotic These smears should be gram stained so as to differentiate the gram negative forms from the gram positive micro-organisms The difference of staining characteristics of the bacteria should be of value in determining the choice of antibacterial drugs Cultures of the discharges should be made at this time and studies of the strain sensitivity of the micro-organisms recovered against the various antibiotics should be instituted

Antibiotic therapy should be started at the initial visit, possibly being delayed only long enough for the study of the smear of the discharges Further delay will be detrimental to the welfare of the patient However the antibiotic studies which have been mentioned will be of aid in the event that the initial choice of an antibiotic does not control the infection All of the lesions should be considered potentially contaminated with *Clostridia tetani* and should receive prophylactic treatment against tetanus In the event that the patient has been receiving tetanus immunization and has received a booster dose within the past six months a second booster dose should be administered as soon as possible following the infliction of the bite In the event that the patient has not received a booster dose of tetanus toxoid or has not been immunized with tetanus toxoid, antitetanus serum should be given prophylactically

Probably the most dreaded complication resulting from the bite of a domestic animal is that of rabies or hydrophobia This is more commonly associated with

dog bites but has followed bites of most domestic animals including the rat, cat, and others.

The treatment of rabies is entirely prophylactic at the present This consists principally of watchful waiting unless the animal inflicting the bite is known to be contaminated with rabies or to have rabies itself

The incubation period of rabies in man varies tremendously usually being from fourteen to ninety days but this is somewhat determined by the location of the wound In some instances it may be of shorter or of longer duration Bites on the head and neck and other exposed surfaces of the body seem to have a shorter incubation period than those of the lower extremities However inasmuch as the incubation period in animals and the whole course of the disease is usually shorter than that of the incubation period in man the practice of observation of the animal inflicting the wound is within good reasonable judgment All mammals are susceptible to the disease

One of the most important prophylactic measures to be taken is the observation of the animal over a period of ten days to two weeks. The animal should not be killed for studies of the brain However if the animal dies of infection during the period of observation studies of the brain tissues should then be made In the event that the animal is killed or disappears the question of whether or not Pasteur antirabic therapy should be instituted will depend entirely upon the judgment of the attending physician In most instances antirabic therapy should be instituted under these conditions for it is highly possible that the animal has sought isolation because of an illness, and may have died a few days after its disappearance. In the event that a dog is killed such as by being struck by an automobile or some other accidental method studies of the animal's brain should be made However if such studies are not available antirabic prophylactic therapy should be begun Since the attending physician's judgment must be guided by the history of the animal all information pertaining to this animal which is available should be made known to him The administration of the Pasteur therapy is not without its dangers and should be instituted only when there is a real fear of the patient possibly having been inoculated with the rabies virus

Rat Bite Fever: The infection known as rat bite fever is a systemic infection which results from the bite of a rat or some other rodent, including weasel and fur squirrel and the cat in isolated cases. Rat bite fever has a world-wide distribution

The earliest cases reported in the United States were those of Blumer[3] who found reference to the disease in 1830 Bayne Jones[4] in 1931 found eighty-one cases that have occurred in the United States over a period of ninety years. His total twenty-nine cases making a total of 110 in the literature as of 1941

The etiology of rat bite fever is a spirochete micro-organism known as *Spirillum minus* or *Spirochaeta morsus muris* The micro-organism has been found in the wound at the site of the bite and the regional lymph, and occasionally in the axillary glands and the circulating blood The usual laboratory technics in culturing bacterial micro-organisms are inadequate to demonstrate the *Spirillum minus* The best method to demonstrate this micro-organism is to inoculate it under the skin of an animal. In about two weeks this spirochete may be demonstrated in the blood of the

animal by dark field or stain preparations.

In 1934 Scharles and Seastone[7] in reporting cases of Haverhill fever made a note of the history of a rat bite in one of their cases Since that time other authentic reports of this disease following the bite of a rat have been made. It is now known that this fever is often the result of a rat bite as well as being, in some instances milk-borne

The clinical manifestations of these two types of fever resulting from bites of rats and other domestic animals differ from each other Both of them result from the bite of an animal. In the instance of the *Spirillum minus* infection the incubation period is considerably longer than that of the incubation period for Haverhill fever In the first instance the incubation is from ten to twenty or more days, whereas in the second infection it is usually between two and ten days The bite promptly heals in those cases of Haverhill fever whereas in those due to *Spirillum minus* there is an associated induration ulceration, slow healing, and regional lymphangitis Both of them usually have severe symptoms with high fever However in the case of the Haverhill type of infection the fever usually is very prompt, whereas in the case of the spirillum infection it is somewhat slower in onset, and usually not quite as severe Haverhill fever has usually multiple or polyarthritic symptoms whereas in rat bite fever due to the spirillum this is a very rare complication Leukocytosis is usually marked with Haverhill fever and only slight in rat bite fever

The treatment of these infections should be principally prophylactic The prophylactic treatment is directed at the destruction and elimination of all rats from domestic life Once the bite has been inflicted, prompt treatment will often result in the prevention of the development of this infection This treatment should be thorough cleansing of the wound cauterization of the wound as previously advocated is no longer necessary If the wound is small, complete excision of the lesion is possible. However inasmuch as these wounds are of a penetrating puncture type and no information as to the depth of the wound is available excision often will not result in its thorough cleansing Prophylactically the use of penicillin should be of tremendous assistance in controlling the spirillum and the streptobacillus types of these infections. The treatment once established, should be directed at the systemic manifestations with parenteral administration of a suitable antibiotic, principally penicillin

Cat Scratch Disease:* While cat scratch disease is not due to the bite of an animal but to the scratch of a cat, it would seem to belong in a chapter containing rabies and rat-bite disease It was described by Daniels *et al*[8] as follows

"A cutaneous lesion has occurred in approximately half the cases. When present it is likely to develop at the site of a scratch or other skin injury It may consist of a slightly raised erythematous nodule or plaque surmounted by a vesicle, pustule or scab At times it may simulate a furuncle This cutaneous lesion usually appears within a few days of inoculation, but rarely its development has been delayed until after adenopathy appears

"The next phase is regional adenopathy which is present four days to more than a month following the initial skin injury One or more regional lymph

* Editorial addition

nodes may become so enlarged as to be evident on simple inspection." They may become as large as a tangerine.

"In the limbs adenopathy is unilateral, involving the epitrochlear and axillary regions in one instance or the femoral or inguinal regions in another. More than half of the reported cases however have involved the nodes of the head and neck: the anterior cervical, the submaxillary, the submental, or occasionally the occipital nodes. In these cases the distribution is more usually bilateral. The nodes may remain movable and nontender. They may become involved in periadenitis with extreme tenderness, heat, warmth and swelling. From this phase they may progress to suppuration. Depending upon the severity of the adenopathy the disease may last from weeks to months. All fistulas eventually heal spontaneously, leaving only a slight scar.

"At no time does the patient appear severely ill, although in the early stages the temperature may be moderately elevated and occasionally reach 104° F (40° C.). Some patients give no history of fever. Headache is common. Chills occur occasionally. Rarely a rash, either macular or vesicular, appears early in the disease, lasting about forty-eight hours. The leukocyte count is usually normal but may be slightly elevated. Erythema nodosum has been described."

The causative agent has not been found. Many writers have commented on the similarity of this entity to lymphogranuloma inguinale. The microscopic appearance of the nodules is not diagnostic.

TREATMENT. Penicillin, streptomycin and the sulfonamides have been reported as valueless by many writers. Chloramphenicol and aureomycin have been reported as giving beneficial results.

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SECTION X

MANAGEMENT OF CASUALTIES RESULTING FROM BOMBING AND SIMILAR CATASTROPHES

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63

Debridement and Emergency Treatment of Wounds and Lacerations

WOUNDS and lacerations occur as the result of accidents or by hostile design Perhaps the greatest source of accidental injuries requiring major surgical therapy is the automobile with industry a close second. Household activities and sports contribute a generous share. Injuries sustained as the result of combat are seen in great numbers during warfare and in time of peace they occur in some communities with considerable frequency through personal encounter

The seriousness of a wound or laceration depends first of all upon the parts affected and the extent of the injury The instrument by which the injury is produced is likewise an important factor in the character and extent of the wound A wound produced by a sharp cutting instrument, for example is not as serious as a similar injury caused by a tearing or contusive force or by a high velocity missile

Wounds and lacerations may be classified as penetrating or nonpenetrating depending upon whether the producing instrument actually breaks through the integument of the body and enters it or simply comes in contact with the body with sufficient force to cause the rupture of some internal structure In either case, the amount of force involved is important.

When a penetrating wound is caused by a flying missile, such as a bullet or a shell fragment, the extent of damage it causes depends upon the mass of the missile and its velocity the force involved being measured by the mass times the velocity As the velocity increases however the resulting force or energy is measured by the mass times the square or higher power of the velocity [1,2] This increase in force that goes with increased velocity accounts for the great destruction of tissues by high velocity missiles The effect is almost explosive a high velocity bullet passing through muscle or other soft parts leaves a zone of destruction much wider than the actual path of the bullet.

For practical purposes all wounds and lacerations have two constant characteristics there is always some devitalization of tissue and always some degree of bacterial contamination and the rate of healing of a wound depends a great deal upon the extent of devitalization and the amount of contamination. If both are minimal, healing without active infection or further tissue necrosis

may be anticipated If however either the one or the other or both are extensive, an unfavorable course can be predicted unless corrective measures are taken. Devitalized tissue favors infection and infection causes further devitalization To put it another way if pathogenic bacteria and dead tissue are permitted to exist together active infection is almost a certainty

Our primary objective in the emergency treatment of wounds and lacerations, therefore, is to provide favorable conditions for healing by removing the dead tissue upon which the bacteria thrive and at the same time reduce the number of bacteria actually in the wound Living vital tissue is not easy prey for bacteria unless the contamination is overwhelming. In the absence of suitable pabulum organisms fail to multiply and ultimately succumb to the natural defensive forces of the body

The emergency treatment of wounds and lacerations, therefore, begins with the removal of foreign material and the excision of the dead tissue which supports bacterial life This operation is ordinarily called debridement though the term is hardly descriptive of the procedure actually carried out Debridement as originally employed by the French surgeons of World War I [2,4-6] literally meant the unbridling or freeing of the wound from constriction and actually consisted of no more than the making of incisions at the margins of the wound to relieve the tension and compression of tissues due to edema The increased resistance to infection came about largely through the resulting improvement of blood supply better drainage of the wound and the incidental removal of foreign bodies

The operation was gradually extended to include the excision of devitalized tissues as well as foreign material[4,7,8,9] but the name debridement which was originally used to describe a simpler procedure was used also to designate the more extensive operation Other terms such as wound excision have been proposed as being more descriptive of what is actually done but they have not supplanted the original term "debridement."

As the value of debridement or wound excision became established during World War I there was perhaps a tendency to overextend its beneficial potentialities and the excision sometimes included tissues which might well have been spared. This was particularly true of skin and bone fragments

The removal of devitalized tissues proved an easier task than that of dealing with the bacterial contamination. Large numbers of bacteria were mechanically removed during the process of debridement but as a rule further disinfection by the Carrel Dakin[10,11] method was necessary before the wound could be closed. As the efficiency of "mechanical" sterilization[12] increased however a number of the surgeons of World War I[13,14,15,16,17,18] performed immediate closure of wounds in selected cases with a high degree of success For the most part, however wounds were left open and treated by irrigation with sodium hypochlorite (Dakin's solution) until they were sufficiently clean to permit secondary closure

The wounded of World War II had from the beginning the benefits of debridement as practiced in World War I with subsequent improvements They had in addition the great boon of incredible drugs that were effective in suppressing or destroying pathogenic bacteria The net result was a great saving of life and a significant reduction

of morbidity and disability Certain modifications were made in the performance of debridement. The large and unnecessary excision of skin edges and of bone fragments was avoided and emphasis was placed upon the immediate correction of certain disfiguring and disabling wounds, particularly those of the face and hands Attention was given also to measures designed to secure rapid healing of wounds either through primary delayed primary or early secondary closure or by skin grafting.

The debridement of wounds as currently interpreted, is carried out as follows

1 The skin edges if devitalized are trimmed or excised with a sharp knife Extensive devitalization of the skin is unusual and it is seldom necessary to excise a margin of more than a few millimeters Avascularity of the skin is indicated by deep blue or black discoloration and by absence of oozing when it is cut. No viable skin should be sacrificed.

2 Devitalized subcutaneous fat is excised, preferably with sharp scissors. The excision is conducted piecemeal, the approach being from within the wound. Loss of viability of fat is indicated by disorganization of the normal lobulated structure, with partial liquefaction, and failure to bleed when cut.

3 Dead muscle is likewise excised from within the wound The actual removal is most satisfactorily performed with sharp scissors which are used to trim away the devitalized portions The dead muscle usually appears black or dark red. It is sometimes described as brick red in color Functionally it is devoid of contractility and when cut there is neither bleeding nor the twitching that is seen in living muscle As the debridement proceeds bleeding and contractility are observed when living muscle is reached.

4 Blood vessels of significant size and importance occasionally are found intact at the periphery of a wound or stretched across it. In such cases the dead tissue about the circumference of the vessel is excised with care The vessel may be in a state of contraction due to traumatic spasm[19] and appear functionless It should not, however be sacrificed upon the assumption that it is useless. After debridement, function may return or be restored if the vessel can be covered with soft parts or otherwise protected from exposure to the air

5 Nerves are treated with even greater consideration than that recommended for blood vessels. Collateral vessels may take care of the blood supply to a part but there is no collateral nerve supply Debridement about a nerve should be limited to what is essential and if possible the integument of the nerve as well as the nerve itself should be preserved. Nerves like blood vessels should be covered with soft parts if possible and prevented from drying

6 Bones which have been exposed without fracture should be disturbed as little as possible Excision of adjacent devitalized soft parts with meticulous attention to the removal of foreign material should be adequate If however there is a fracture and particularly if it is compounded, comminuted, or both, the problem is more complicated. Dead soft parts must be excised as usual, but bone fragments must be preserved particularly so if their removal would compromise the continuity length, or subsequent stability of the bone The bone fragments are seldom devitalized even when almost completely detached and

if the fragments can be freed of foreign material and gross bacterial contamination they as a rule, will survive The importance of thoroughness in the mechanical cleaning of the fragments is obvious It is a great advantage if enough soft tissue remain to cover the site of fracture if this is not the case split skin grafts are useful to provide temporary covering [20,21] Effective immobilization is essential. The judicious use of antibiotics is helpful in the prevention of infection

7 *Joints that* have been opened as the result of trauma require the same considerations that have been outlined for the treatment of compound fractures The removal of foreign bodies large and small and thorough irrigation of the joint space with normal salt solution are important measures If possible the opening in the synovial membrane of the joint should be closed [14,19,22,23,24] Contrary to a rather widespread impression the synovia of a joint shows considerable resistance to infection A drain should never be inserted into a joint and the instillation of antibiotics is more productive of harm than good.

The proper debridement of wounds frequently requires that they be made larger to permit the thorough removal of dead tissue and foreign bodies from the deeper recesses This is particularly true of extensive deep wounds with relatively small portals of entry In this situation it is far better to extend the wound by suitable incisions than to do an incomplete debridement or use excessive retraction in an attempt to get adequate exposure Injudicious retraction may traumatize living tissues to the point of devitalization and in some measure defeat the object of the operation

A further point pertaining to the general principles of debridement is the fact that the zone of devitalization in a wound is never uniform in width or depth. At one point tissue destruction may be extensive whereas at another it may be minimal This is a reason why debridement should be conducted from within the wound *even though this approach* may seem illogical from the standpoint of contamination An attempt to excise a wound *in toto* somewhat as one might *remove a tumor* would involve unnecessary destruction of tissue and *at the same time might* fail to remove completely the dead tissue from certain parts of the wound.

With this brief review of the history and general principles of debridement in the treatment of wounds, its practical application to some of the more specific injuries encountered in surgical practice will be considered

HEAD

Scalp Wounds and lacerations of the scalp as a rule present no great difficulty The blood supply is abundant and in spite of bacterial contamination from the hair infection seldom occurs, provided a wide zone of hair about the wound is shaved all foreign material is removed and the wound is thoroughly cleansed with normal salin Strong bactericides are lethal to tissue cells as well as to pathogenic organisms and are not to be recommended The debridement required is minimal because devitalization of the highly vascular tissues of the scalp is minimal

If a simple fracture of the skull is associated with a scalp wound no specific surgical measures are required If the fracture is comminuted or depressed it is safer as a rule not to remove or disturb the fragments If removal or elevation of fragments is necessary it is

better that it be done later by a competent neurosurgeon rather than as an emergency procedure

The scalping accidents which occasionally occur require special consideration. As a rule, they are caused by the long hair of a female employee becoming caught in revolving machinery These accidents are especially distressing because of the permanent loss of hair and the slow healing of the extensive wound. If the patient is seen soon after the accident, an attempt should be made to use the scalp as a full thickness skin graft to cover the defect.

Davis[25] has stated that he knew of no authentic record of a case of complete scalping in which the replaced scalp had survived. Nevertheless, under favorable conditions, survival does not seem an impossibility The detached scalp should be shaved and the raw surface trimmed until only the skin with its hair follicles remains The chance of viability of the graft should be improved by the decortication of any exposed areas of skull before the graft is applied. After the graft has been carefully sutured in place, a thick covering of sheet cotton very wet with normal salt solution should be applied and the whole enclosed in a suitable sterile dressing. Small rubber tubes should be incorporated in the dressing to permit continued moistening of the cotton with salt solution. If the avulsed scalp obviously is not viable when the patient is first seen the denuded area, including exposed bone, should be covered with split skin grafts taken from any convenient part of the body

Forehead. Lacerations of the forehead often occur in connection with injuries of the scalp and face and the principles of treatment are essentially the same. There is rarely sufficient loss of skin to require grafting and little debridement is needed. It is sometimes advantageous to excise contused wound edges in order to get better primary healing. The suturing should be done with fine materials and the sutures should be placed near the skin edges to avoid wide cross-hatched scars they should also be passed in a direction perpendicular to the skin on each side of the wound so that the entire thickness of skin is included in each stitch, and accurate apposition obtained. If the hairlines of the scalp or eyebrows are involved, attention should be given to exact restoration of the normal line. Temporal lacerations which may involve the frontal branch of the facial nerve should likewise be sutured accurately Care exercised at the initial repair often makes secondary revisions unnecessary

Face Cuts and lacerations of the face are common sequellae of automobile accidents and are often associated with fractures Treatment begins with thorough cleansing, special attention being given to the removal of any foreign materials such as grease and dirt which may cause permanent tattoo marks If the wound is of the abrasive type the use of a brush with soap and water or a mild detergent may be necessary for the removal of all foreign matter but it should be remembered that the best chance of complete removal is at the initial emergency treatment.

Deeper wounds and lacerations are treated in conformity with that outlined for the forehead. Debridement, if used at all, should be confined to the removal of bits of skin and tissue that are unquestionably devitalized. In suturing the wound it is sometimes advisable or necessary to use very fine catgut sutures to approximate subcutaneous tissues even if the wounds have little

depth the particular advantage is to provide a substantial supporting structure for the skin and thereby avoid subsequent areas of depression If there has been actual loss of tissue making closure without deformity impossible, any exposed area should be covered by a split skin graft to secure prompt healing and avoid excessive scar formation. If the loss of tissue is extensive and involves the buccal mucosa causing a large fistula the skin edges around the wound should be sutured to the underlying margin of mucosa to eliminate raw surfaces and to obtain prompt temporary healing with minimal scar formation This procedure will provide satisfactory conditions for subsequent plastic work and will shorten the time before it can be started

The facial nerve is not often severed in accidental wounds of the face but occurs occasionally as the result of slashes with a knife or razor It is surprising how seldom permanent facial paralysis follows such injuries even if the ends of the nerves are not identified and accurately approximated. In any wound or laceration involving the facial nerve however a serious attempt should be made to find the nerve ends and bring them together with perineural sutures of fine silk.

NOSE The nose is the most prominent of the facial features and scars or deformities are quite noticeable For this reason great care should be exercised to make restoration after injury as complete as possible A further consideration in the treatment of nasal injuries is the fact that nasal cartilage is susceptible to infection and if infection occurs there may be loss of cartilage with resulting deformity which is difficult to correct

If an injury has caused actual loss of nasal skin and soft parts, or cartilage temporary skin grafting should be done. If the loss involves mucosa to any extent, temporary healing should be the objective with plastic work to follow

Fractures of nasal bones should be corrected at the earliest possible moment before scarring of the soft parts or partial union of the fractures in malposition makes the task difficult, if not impossible In simple fractures of the nose moulding of the fragments into position is ordinarily not difficult but if there are also fractures of the maxillae reduction may be quite a problem particularly so if the features are depressed, and the services of a competent plastic surgeon should be sought.

EYELIDS Time spent in the meticulous repair of lacerated eyelids will be rewarded by results better than could be obtained by secondary procedures. If the laceration involves the skin alone fine interrupted silk sutures should be used for reapproximation If the laceration involves the full thickness of the lid the conjunctiva should be sutured as a separate layer with fine interrupted silk sutures which are tied on the conjunctival side If the rent extends onto the bulbar conjunctiva particular attention should be given to accuracy of approximation at the conjunctival fold to prevent posterior symblepharon [8] In lacerations of this extent, the aid of a qualified ophthalmologist should be sought.

LIPS In accidents involving the face lacerations of the lips often with considerable contusion of tissues, are frequent The lips are often driven against the teeth producing a through and through laceration. The repair of injuries of the lips usually offers no particular problem except that of accurately

restoring the vermilion borders If the margins of the laceration are ragged or if much swelling is present identification of the vermilion line may be difficult and the repair somewhat complicated. If extensive loss of tissue has occurred it is not advisable as a rule to attempt reconstructive measures immediately after the accident. The skin about the defect should be sutured to mucosa to secure prompt healing and definite repair deferred until it can be undertaken as a planned procedure

Ears. The partial or complete loss of an ear occasionally happens as the result of an automobile or a riding accident in which the victim is thrown in such a way that he skids along a hard surface on his ear In such instances the ear may be so badly damaged that salvage is out of the question Any viable remnants should be restored as completely as possible to normal contour and relationships because the reconstruction of an ear is one of the most difficult problems of plastic surgery [7,25] Many attempts have been made to restore by immediate suture portions of the ear which have been completely torn off Such efforts are fruitless except when the severed portions are small, and the time between injury and repair is short.

Whatever is to be done by way of repair should be done with the least possible delay because partially separated parts may remain viable if restored promptly but are likely to die if restoration is delayed until drying and thrombosis have occurred. Particular attention should be given to the cleansing and handling of auricular cartilage because of its importance in the maintenance of the shape of the ear It is susceptible to infection and may be lost through sloughing if infection occurs

NECK

The neck is a relatively exposed part of the body and contains a number of structures whose functioning is vital to life Virtually all outside substances that sustain life pass through cervical structures before they can be used by the body Wounds of the neck occur frequently in fights because adversaries are well aware of the vital nature of the cervical structures Persons intent on suicide may likewise select the neck as a vulnerable part of the anatomy

Wounds and lacerations of the neck may involve essential blood vessels the trachea, the esophagus important nerves, or many combinations of these structures

Blood Vessels If damage to blood vessels of the neck involves veins alone an important amount of blood may be lost in a short time particularly if the internal jugular is opened, but the flow is not under great pressure and often can be controlled temporarily by the application of an improvised dressing A compression bandage may be applied over a tampon and made tight enough to stop venous bleeding but still permit the patient to breathe Point pressure applied with or without a dressing by means of the finger is often effective until more definitive measures can be taken If however an important artery has been severed, control is more difficult and the patient is likely to succumb digital compression, clamping, or ligation may prove effective

There is seldom opportunity for the suturing of vascular injuries in the neck and clamping with ligation is virtually the only practicable means of more than temporary control.

Trachea Division or opening of the trachea is not necessarily fatal but the

patient may drown in his own blood or suffocate from blocking of the trachea by lacerated tissue. Repair by suture is usually effective if other serious injuries are not present.

Esophagus. The esophagus is rarely severed without grave injuries to other structures of the neck. It may be penetrated, however, by a narrow bladed knife or a dagger without serious injury to other parts. Simple suture supported by antibiotic therapy is usually effective in either severance or puncture of the esophagus if the patient can be treated within six to eight hours after the accident.

Injury and perforation of the esophagus occur more often from the swallowing of sharp pointed objects such as chicken or fish bones or as the result of instrumentation. The chief danger in either case is failure to recognize the injury promptly. If the wound is very small and is discovered immediately, the withholding of food and drink and the use of broad spectrum antibiotics may be adequate treatment, but in any case it is safer to close the wound surgically if possible. If recognition of any esophageal wound is long delayed, active infection with cellulitis or abscess is probable and surgical drainage becomes necessary. For further discussion of this subject see Chapters 9 and 18.

THORAX

Nonpenetrating Wounds. Wounds of the thorax which do not enter the pleura are treated in much the same manner as similar wounds elsewhere. Compound fractures of the ribs may interfere seriously with respiration and require oxygen therapy in addition to local treatment. It is rare, however, to have compound fractures of thoracic bones without a concomitant opening of the pleural cavity and pneumothorax.

Penetrating Wounds. Penetrating wounds of the thorax, if large, admit air to the space between the lung and parietal pleura and cause immediate partial or complete collapse of the lung. There is likely to be also a sudden shift of the mediastinum toward the unaffected side. The displacement of the mediastinum increases with each inspiratory effort resulting in mediastinal flutter and severe limitation of the vital capacity of the corresponding lung. This sequence of events may cause immediate or delayed fatality. It may happen also that the penetrating wound of the thorax admits air to the pleural cavity with each inspiratory effort without permitting egress on expiration. In this manner air accumulates in the chest and exerts pressure on the heart, the mediastinum, and the unaffected lung causing severe embarrassment of the cardiorespiratory functions. The danger is increased if the lung also has been injured. Small penetrating wounds often seal themselves off and may not produce a pneumothorax (see Chapter 15).

Another important immediate complication of chest wounds is hemorrhage from an intercostal or internal mammary vessel or from the lung itself. Blood accumulates in the pleural cavity, compresses the lung and causes respiratory embarrassment. The actual loss of blood also may be sufficient to put the patient in a state of shock which should be treated by arrest of the hemorrhage if possible and replacement of lost blood and fluids.[79] Blood aspirated from the patient's chest may be used for autotransfusion if other sources are not available.[20]

In the presence of pneumothorax or hemothorax or both sufficient to pro-

duce demonstrable or symptomatic compression of the lung, the chest should be aspirated as completely as possible and as often as necessary to relieve the respiratory embarrassment. If pneumothorax is the principal problem it is best met by inserting a small soft rubber tube through the second intercostal space anteriorly and connecting it for under water drainage.[30]

The treatment of open wounds of the chest requires considerable judgment and ability to visualize what has happened and what is happening at the time In the case of a sucking wound it is important to close the opening in the chest wall as promptly as the patient's condition permits Closure by suture, however is inadvisable unless all the necessary surgery has been completed.[31] Temporary closure can be effected by means of a pad of petrolatum gauze or even wet gauze strapped to the chest wall by adhesive or fixed by suture

If the lung fails to expand after closure of the chest wall, it is probable that it has been lacerated and is leaking air blood, or both. Under favorable circumstances the chest should then be opened to permit discovery and suture of the leak. If the surgical conditions and the state of the patient are not favorable it is better to continue with the conservative measures outlined until a more positive approach can be undertaken with reasonable safety

The large, open, sucking chest wound is uncommon in civilian practice Most of the thoracic injuries encountered are of the small puncture type and the lacerations of the chest wall and lung often close spontaneously The treatment is directed mainly toward combatting hemorrhage and shock and the relief of pneumo- and hemothorax.

Wounds of the Heart Most wounds and lacerations of the heart cause immediate death. If the wound is small however bleeding may be less profuse and the escape may be external or into the pleural cavity In some cases the wound in the pericardium becomes sealed and blood accumulates in the pericardial sac giving rise to the condition known as cardiac tamponade Surrounded and compressed by blood the heart cannot fully expand during diastole to receive blood from the great veins and its output is correspondingly diminished. The outstanding symptoms and signs[32] are

1 Usually a history of absence of symptoms for several minutes after injury followed by rapid collapse

2 Weak pulse and heart sounds

3 Low arterial pressure.

4 High venous pressure

5 Absence of visible pulsations under fluoroscopy[33]

The treatment formerly recommended was immediate operation.[29] More recently however there has been a trend toward more conservative measures, mainly treatment by aspiration[34,35] Aspiration is by far the simpler treatment and is quite effective unless the pericardial blood is clotted. Operation is best conducted under general anesthesia and through a transverse incision carried across the sternum at the level of the fourth costal cartilage[32] Costal cartilages and sternal bone are removed to secure good exposure and the wound in the heart is sutured with fine silk. The sutures are tied with sufficient tension to arrest the bleeding but not tightly enough to cut through the myocardium. For a more detailed discussion the reader is referred to Chapter 17

ABDOMEN

The treatment of wounds of the abdominal wall present no great problem

unless they expose or open the peritoneum and permit the extrusion of the abdominal contents usually the intestines Even then, the prognosis is relatively good if the viscera have not been lacerated and if repair is effected promptly In the occasional case in which there is extensive loss of the abdominal musculature it becomes necessary to retain the intra abdominal contents by means of tantalum wire mesh or other suitable substitute for the normal structures

Rupture or Laceration of the Spleen The spleen is frequently ruptured in contusive accidents and is occasionally *lacerated as the result of a penetrating* wound. It may also rupture spontaneously in malaria, certain enteric fevers and infectious mononucleosis In rupture or laceration from any cause removal of the spleen is necessary to arrest existing hemorrhage or to prevent the possibility of delayed hemorrhage The diagnosis is made from the location and nature of the injury and from evidence of intra-abdominal bleeding The best approach in accidental cases probably is a long left paramedian incision which permits the examination of other viscera for injuries The splenic pedicle should be grasped with the fingers and held until it can be ligated.

Rupture or Laceration of the Liver The liver cannot be removed and persistent hemorrhage from ruptures or lacerations must be arrested through repair or packing. Fortunately bleeding from the liver is not under great pressure unless arteries are involved, and sutures placed fairly superficially through the capsule and underlying liver substances are often sufficient to stop the flow If the laceration is in an inaccessible part of the liver packing with gelfoam or oxycel gauze is usually effective (see Chapter 25)

Stomach Duodenum and Small Intestine Ruptures and lacerations of the stomach, duodenum and small bowel may occur either as the result of penetrating wounds or from external violence Wounds of these proximal parts of the digestive tract are treated by simple suture without drainage Occasionally the wounds in a segment of small bowel may be so numerous or extensive particularly in the case of gunshot wounds that resection is necessary It is important not to overlook a perforation since a single omission may well prove fatal *In the case of gunshot wounds, the* finding of one hole in a hollow viscus usually means that another representing either the wound of entrance or exit is present. Duodenal ruptures or perforations are particularly likely to be missed because the greater part of this segment of intestine is retroperitoneal Intestinal contents spilled in the peritoneal cavity should be carefully removed by suction and by sponging with gauze but no attempt should be made to remove the material by washing or irrigation The *insertion of drains into the abdominal cavity in such cases serves no useful* purpose

Colon and Rectum Perforations and ruptures of the proximal half of the colon usually can be sutured with relative safety if treated early and if not extensive Perforations of the left half of the colon are more serious because of the heavy bacterial contamination Small perforations seen within six hours usually can be treated by primary suture but if the wound is extensive or *treatment is delayed, exteriorization of* the injured segment by simple loop colostomy is a safer procedure

Rectal wounds should be debrided and if possible the opening in the rectal wall should be sutured. The wound of the soft parts, however should be left open The feces should be diverted from the rectum in all cases by complete proximal colostomy at a suitable level.

UROGENITAL SYSTEM

Urinary Tract. The treatment of wounds and lacerations of the urogenital organs should be basically conservative. A ruptured kidney should not be sacrificed except in extreme emergency unless it can be determined that the other kidney is present and adequately functional. There is always the possibility that the injured kidney is the only kidney

Injuries to the ureters like those of the kidney should be treated by repair if possible rather than by sacrifice of the corresponding kidney A partial or complete division of a ureter should be mended by suture over a ureteral catheter If for any reason retrograde catheterization of the ureter is not possible at the time the catheter can be introduced through the wound in the ureter and passed upward toward the kidney and down the ureter into the bladder where it curls up and can be removed later by cystoscopy If the injury to the ureter is quite near the bladder it is often possible to reimplant the proximal end of the ureter into the fundus of the bladder and ligate the distal stump

Perforating wounds or ruptures of the bladder can be treated successfully as a rule, by simple inverting sutures followed by continuous drainage of the bladder by means of a retention catheter

Lacerations involving the urethra should be repaired over a catheter of the retention type which can be left in place until healing is secure A more extensive discussion of urological emergencies is found in Chapter 51

Genital System Wounds of the ovaries and testes should be repaired and the gland conserved even if only a small portion remains. The fact that the patient has a sound ovary or testicle on the opposite side is poor reason to remove unnecessarily the injured gland.

Injuries of the vulva, vagina, penis and scrotum should be repaired by suture or if necessary by skin grafting. Occasionally the skin of the penis or scrotum is caught in revolving machinery and is completely stripped off In such cases the denuded areas should be grafted immediately with the most elastic skin available, due consideration being given to functional requirements

Lacerations, perforations and ruptures of the uterus usually can be repaired without hysterectomy particularly so if blood is available for adequate transfusion. A simple minute perforation of the uterus of the type that sometimes occurs in the operating room during the course of a curettage does not necessarily require exploratory laparotomy unless there is evidence of injury to the intestinal tract or other viscera, and/or severe hemorrhage

THE EXTREMITIES

The treatment of wounds and lacerations affecting the extremities has been largely covered in the introductory paragraphs which dealt with the treatment of injuries to special tissues It is sufficient at this point to remember that

1 Immediate and accurate repair of nerves tendons muscles, joint structures, and major blood vessels is highly important if the best results are to be obtained.

2 That debridement should be concerned with foreign bodies and devitalized tissues alone and that all living tissues should be preserved.

3 That all exposed tissues should be covered by suturing the adjacent soft parts and skin over them or by skin grafts This is particularly important with respect to wounds and lacerations of the hands

4 That when permanent partial disability is unavoidable the part should be put up in the position of greatest functional usefulness.

5 Obtaining and preserving the function in an injured hand is so important that nothing which furthers that objective should be overlooked or omitted. Repair of all injured parts particularly severed nerves and tendons should be immediate and complete

The emergency treatment of wounds and lacerations is too large a subject to be covered briefly except by a general outline of principles Infinite varieties of injuries and combinations of injuries are encountered in peace and in war, but if there is an understanding of the anatomy and functions of the parts involved and their reactions to injury no insurmountable difficulties should be encountered in giving competent emergency treatment in almost any situation. Great responsibility rests upon the surgeon who first treats the injured patient. It is rarely possible by any subsequent measures to do as much for the patient's future well being as can be done at the first operation. The immediate careful cleansing of wounds and the painstaking restoration of surviving tissues to their normal relationships are matters of the greatest importance Failure to recognize the extent of an injury or an indifferent repair may result in a lifelong handicap to the patient or even cost him his life

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The Treatment of Burns

UNDOUBTEDLY the treatment of thermal injury has been of interest since the discovery of the uses of fire by prehistoric man In spite of the antiquity of the lesion standardization of the basic principles of primary treatment has been slow During a ten-year period we have seen the tanning method discarded in favor of treatment with pressure dressings, which method in turn has been supplanted in many centers by exposure therapy The improved prognosis for the survival of the burned patient and for the restoration of his function has been more the result of apparently solid advances in many details of treatment rather than a single important specific discovery A more sensible attitude has developed with regard to the local lesion so that valueless or even harmful medications are not put on it The antibiotics have been available to minimize infection efficient methods of skin grafting have been discovered and the value of blood volume replacement in certain severe cases has been recognized

Pathology of Burns The pathology in burns is simple and for practical purposes may be considered to be confined to the tissues directly affected by the heat or chemical agent. There are no specific effects on liver kidney brain or adrenal which need worry the surgeon The liver necrosis observed during the tannic acid era (1925-1942) was of course due entirely to that treatment.[1] Important kidney damage invariably has been associated with sulfonamide administration or transfusion with incompatible blood. Curling s ulcer of the duodenum may now properly be called a "stress ulcer" and probably most of these observed in the past have been due more to the apprehension and trauma of the needless periodic dressings which surgeons once insisted on, rather than to the burn itself

Traditionally the lesions of burns have been classified as being of first, second and third degree It is advantageous to subdivide second degree burns into those which are superficial and those which are deep A burn which results in only a painful erythema of the skin and which heals in a few days with light desquamation (e g the peeling of a mild sunburn) is called a first degree burn If blisters form (exudation of plasma underneath the cornified layer of epidermis) but healing takes place without a trace of residual scarring the lesion is classified as a burn of superficial second degree (Fig 1) If the injury is deeper with or without blisters so that the healing time is prolonged until after the sloughing of por



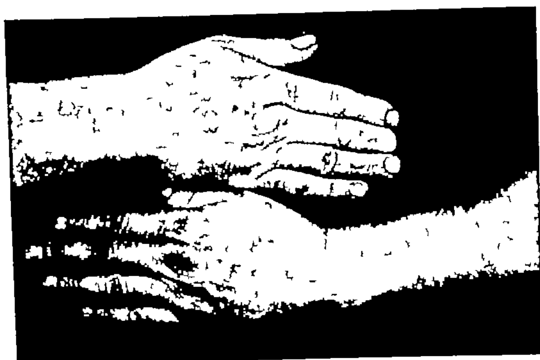


FIG. 1 First and superficial second degree burn of right hand from flame. Lower picture, result two weeks later after treatment with occlusive pressure dressing. Uninjured hand included for comparison.

tions of the skin deeper than the cornified layer we have a deep second degree burn Healing takes place as a result of proliferation of the remaining elements of the epidermis and the residual is light scarring without contracture The back of the patient shown in Fig. 2 illustrates this type of healing The burn is said to be of third degree if all layers of the epidermis are destroyed and heal

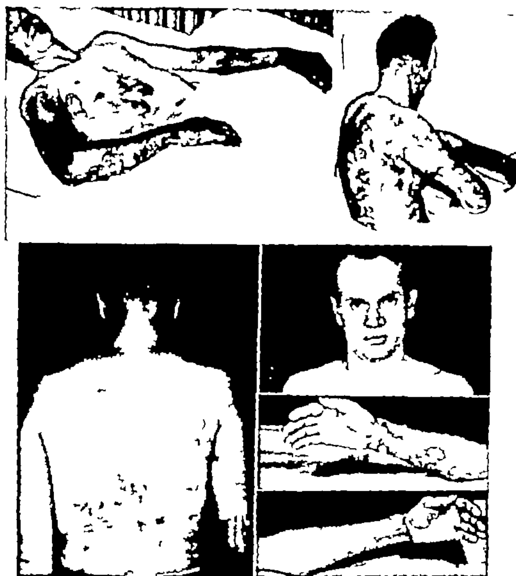


Fig. 2 Patient exhibiting first, second, and third degree burns under treatment by the exposure method. Upper row condition after forty-eight hours of open air treatment. Lower pictures, final result. Note the stamp grafts which were applied to the volar surface of the right forearm.

ing must take place by the formation of scar tissue which is covered with epithelium which grows from the margins of the wound, unless there is timely intervention by the surgeon with skin grafts The skin involved in third degree burn is lifeless and dry and of a yellow brown or black color depending on the duration and degree of the heat. Blisters are not formed because there are no intact blood vessels and lymphatics to transport the exudate and take part in the phenomenon of inflammation In the case of flame burns the superficial epidermis rolls off in dry black sheets (Fig. 3) The period required for spontaneous sloughing varies greatly for different parts of the body Where the skin is thin and the vascularity is great, the necrotic tissue may fall



FIG 3 Almost total third degree burn resulting from an industrial accident (explosion of an electric furnace) This hopelessly burned man lived fifteen hours.

off in a week (Fig 4) Sloughing may be extremely slow when the thick skin of the trunk is involved The deepest burns are those caused by the passage of electric currents through the tissues and they may be associated with total gangrene of parts (Fig. 5)



FIG. 4 Third degree burn from scalding with very early spontaneous separation of slough (one week)

FIRST AID TREATMENT

In many forms of trauma, first aid maneuvers may be remarkably comforting or even life-saving as for example, in the case of hemorrhaging wounds, fractures, or asphyxiation. No comparable benefits are available for burns because of their quality of relative irreversibility with recovery following after weeks of the natural healing process or after sloughing and the grafting of skin by the surgeon In an occasional instance it may be possible to shorten the period of contact with the burning agent by prompt immersion of the subject or part in water The urgency of this would be obvious in the case of flame burns and is equally important where caustic chemical agents are involved.

For the severely burned patient for whom hospitalization is expected, covering the involved area with a clean sheet or towel is about all that can be suggested other than the administration of an analgesic drug if it is available



FIG. 5 Electrical burn from contact with current of 7600 volts. A early appearance of hand showing charring and obvious impending gangrene of forefinger B three weeks later with beginning of spontaneous sloughing. C, condition following final débridement and amputation of finger

Plasma and blood (to combat the largely mythical "primary burn shock") are never necessary during the early hours of the injury

Ideally first aid treatment for minor burns should be identical with good primary definitive treatment, as for example, when a sterile pressure dressing is applied for a burn of the hand. The problem of what medication to put on a burn has been the subject of many articles in the medical literature and the manufacturers recommendations for hundreds of proprietary preparations have filled incalculable amounts of advertising space Several years ago a study was made of the methods of treatment of minor burns in the plants of three large automobile companies[2] It was found that no less than eighty-four different substances were used in the treatment of 5609 burns Moreover it was noted that regardless of what was put on the average minor industrial burn, it was apt to be healed in less than a week Controlled studies on proprietary preparations have shown without exception that they possess no properties which make them therapeutically active[2,4] Examples of some ineffective remedies are the chlorophyll preparations sulfonamide ointments vitamin mixtures for topical application, hydrosulfosol foille, epithene and biodyne

On the basis of the study referred to above the following recommendations for the treatment of minor industrial burns were made

(a) Wash the area with soap and water if it is dirty
(b) Do not break blisters or otherwise "debride" the wound.
(c) Cover with fine mesh gauze impregnated with petrolatum jelly
(d) Apply a firm dressing over this bulky enough to keep dirt away from the injury but not too large to keep the man off his job

Any convenient modification of the above instructions should suffice for the household and other nonindustrial burns Writers on the subject of atomic explosions over populated areas have urged that the public be educated to the fact that the minor burn actually requires no specific treatment and "casualties" with this type of injury should not be allowed to interfere with the expeditious care of serious cases in clearing stations or hospitals[6,7]

TREATMENT OF BURNS IN THE HOSPITAL

It is difficult to define what type of

burn case belongs in the hospital. The availability of a bed rather than the severity of the injury will be the determining factor in many instances Probably as good a rule as any is the Golden Rule Some patients will be admitted because of the large area of skin involved (for example the patients illustrated in Figs 2 and 3) while others with small but deep burns may need early surgical treatment (Figs 4 and 5) In the event of a catastrophe with hundreds or thousands of casualties hopelessly burned patients like the one shown in Fig 3 could be given their token treatment just as well outside a hospital.

Outline of Burn Treatment 1 Immediately Give morphine for pain chart extent of burn and apply dressings or begin exposure treatment.

2. First three days Give attention to blood volume and urinary output antibiotics

3 Next two weeks Give attention to nutrition and continue antibiotics Do not disturb dressings except on burns of minor depth. At end of period, remove dressings. If burns are healed, discharge patient If deep second degree burns are unhealed, replace dressings If sloughing of third degree burns is not complete, apply wet compresses for two days

4 After third week Discharge patient or proceed with skin grafting

Immediate Measures

Analgesic and Sedative Drugs. It has been a common assumption that the pain in all burns is intense and that large doses of opiates are necessary for its relief It is true that during the first half hour the pain of even a small second degree burn may be severe However it has been noted that patients with large areas of third degree burn are relatively comfortable The patient with the almost total third degree burn shown in Fig 3 complained only of chilliness on arrival at the emergency room Morphine remains the drug of choice the average adult will require 16 mg (¼ grain) and this may be repeated with caution in two hours The intravenous route should not be forgotten, since there may be poor absorption from the subcutaneous tissues or muscles in severely injured patients. For this route smaller doses are used (8 to 11 mg [⅛ to 1/6 grain]) For a sedative in the treatment of fear and hysteria, repeated doses of barbiturates intravenously are useful *e.g* sodium pentobarbital in 90 mg. (1½ grain) doses

It is important that one does not try to relieve the restlessness or mania due to anoxia with morphine or the barbiturates Beecher[8] emphasized this point in his account of the management of the Cocoanut Grove victims at the Massachusetts General Hospital. Injury to the respiratory tract was common and it was felt that excessive opiate administration had been detrimental in several cases The following case report is instructive A twelve-year-old boy was sleeping in a tent while on a winter camping expedition. At 4 00 A M a campfire ignited the tent and the boy s bedding and he received deep second degree burns of the face and hands He was admitted to the Henry Ford Hospital the next morning and petrolatum dressings were applied to the burned surfaces It was noted that he was hoarse, a condition which was tentatively attributed to a cold During the following evening and night considerable dyspnea and stridor developed and the next morning an oxygen tent was placed over him. There was no relief of the dyspnea nor was any benefit derived from mask inhalations of an oxygen helium mixture (25 75)

At noon on the second day the boy had become irrational and was thrashing wildly about his bed, fighting at the oxygen tent. A house officer suggested morphine for the extreme restlessness For tunately this suggestion was not carried out but instead a tracheotomy was performed. This permitted normal respirations the patient became rational and lay quietly Henceforth his recovery was uneventful

The application of a firm occlusive dressing to the burn tends to relieve pain and decrease the need for narcotics If the exposure method of treatment is chosen more analgesic agents may have to be given at first, but according to Blocker during the entire period of hospitalization the patients in the open air received only a third as many hypodermic injections as those treated with occlusive dressings [9]

Charting the Area of Burns The diagrams of body areas which were published by Berkow[10] in 1924 have been modified and corrected by others For exceedingly exact computations, the diagrams and tables suggested by Lund and Browder[11] are useful (Figs 6 and 7) These take into account the fact that as the age increases from infancy to adulthood, the lower extremities contribute relatively more to the total body surface and the head less.

Wallace[12] has proposed a simple way of remembering a rough estimation of body surface areas, which he calls the "rule of nine" (Fig 8) The principal

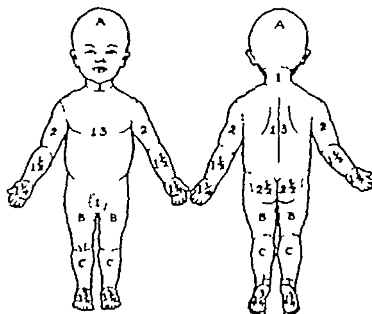


FIG. 6 Lund and Browder's modification of the Berkow chart for surface area estimation. Key to area percentages represented by letters

Area	Newborn	1 yr	5 yrs.
A = ½ of Head	9½	8½	6½
B = ½ of One Thigh	2¾	3¼	4
C = ½ of One Leg	2½	2½	2¾

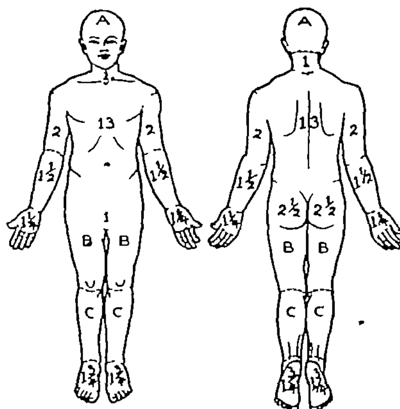


FIG. 7 Lund and Browder's modification of the Berkow chart for surface area estimation. Key to area percentages represented by letters

Area	10 yrs.	15 yrs.	Adult
A = ½ of Head	5½	4½	3½
B = ½ of One Thigh	4¼	4½	4¾
C = ½ of One Leg	3	3¼	3½

divisions of the body are represented as providing nine per cent of the total surface or multiples thereof The head and each arm are nine per cent, each leg is twice nine or eighteen per cent, and the entire trunk is four times nine or thirty six per cent.

Occlusive Dressings· Although remarkably good results are obtained by the exposure method, most peacetime burns will probably continue to receive a primary dressing. The sooner this dressing is applied, the sooner the patient is comfortable and the sooner the danger of infection is minimized. There should be no fear of the overemphasized "burn shock" at this time Experience has shown that there is plenty of time to apply appropriate dressings before there is need for blood volume replacement

The dressing is applied according to the following plan. Unnecessary personnel such as relatives are excused Aseptic technic is followed as far as is practical. This includes the masking of all persons in the room including the patient The burned clothing or first aid dressings are removed, unless the latter are known to be of a satisfactory nature. No débridement or washing is

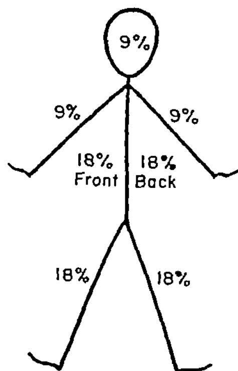


Fig 8 Simplified diagram of Wallace's Rule of Nine for estimating body areas involved in burns. After Evans et al [13]

done The unopened blister with its plasma bathing the underlying burn is probably the ideal dressing. Controlled studies have shown that it is useless to try to remove organisms which have been deposited on the wound since the injury in an attempt to convert the contaminated wound into a sterile one [12] However it should be stated that some surgeons who have had success in the treatment of burns continue to insist on vigorous soap and water cleansing before the application of the dressing [14]

No medication is recommended for the burned surface for the reasons given in the section on first aid treatment. It has been customary to place some type of fine mesh, nonadherent fabric next to the burn Gauze *lightly* impregnated with petrolatum jelly has been used extensively Dry fine mesh gauze (ordinary bandage) or rayon fabric may be used Metal foils such as aluminum or tantalum are actually contraindicated because of their nonporosity which causes maceration and promotes infection The inner layer is followed by folded gauze dressings outside of which is placed some type of bulky padding material such as machinists waste or cotton pads Elastic bandage then completes the pressure dressing (Fig 9)



Fig 9 Steps in the application of a petrolatum gauze-pressure dressing to a deep second degree burn of the arms.

Dressings on the extremities should extend out to the tips of the fingers or toes to minimize swelling of the hands or feet. *In hand dressings, the fingers* should be individualized and the tips should be visible unless they are seriously burned also It must be emphasized that it is possible to apply a "pressure dressing" in an unskilled manner

so that a tourniquet effect is produced or localized areas rendered painful and ischemic by uneven pressure

Burns of the face are far better left exposed to the air The absence of the dressing makes the eyes available for irrigations, the nostrils available for cleansing with cotton-tipped applicators and the mouth available for feeding and for the application of cold cream to the parched lips The results of the exposure method in the face have been so good that it is not surprising that similar treatment for the rest of the body has been tried and found to have many points in its favor

"Open Air" Treatment There is renewed interest in the exposure method of treating burns as a result of the studies of Blocker and his associates[9] in this country and of Wallace[12] of Great Britain The principal advantage seems to lie in the improved prognosis in regard to wound infection which is favored by the warm moist environment under the occlusive dressing

The method is essentially simple The burn is not washed and blisters and shreds of epidermis are not molested The involved areas are exposed to the air in any way which is practical (Fig. 2) For circumferential burns of the trunk, the patient lies on a clean (or sterile) sheet, turning frequently to allow drying of all areas For burns of the lower part of the body some type of cradle to support the bedclothing will be necessary Ambulation for bathroom privileges and meals is permitted in most instances After about two days dry crusts form over the raw areas and they are no longer painful Daily inspection may reveal cracks in the crust with underlying fluid Such areas are trimmed away so that a new adherent scab can form

General Treatment During First Three Days

For about ninety per cent of hospitalized patients, the following simple orders will suffice

1 Diet as tolerated
2 Temperature pulse and respirations recorded every four hours
3 Codeine 60 mg (1 grain) every three hours if necessary for pain.
4 Record urinary output.
5 300 000 units penicillin daily

Blood Volume Replacement About ten per cent of hospitalized patients will have so much injured tissue that there is considerable local loss of plasma and a serious diminution of the amount of circulating blood A measure of this is the hematocrit determination, which may rise from a normal of 45 to 60 65 or even 70 In an extreme situation the extremities may be cold and the pulse at the wrist may be weak. This condition (so-called burn shock) is actually quite rare in clinical practice, partly of course because of the popularity of specific prophylactic treatment with plasma or blood, but also because it will develop in far fewer untreated patients than would be expected when one considers some of the rules for blood volume replacement which have been suggested. For example the [illegible] illustrated in Fig 2 with at [illegible] per cent of the body surface [illegible] not receive blood or plasma [illegible] blood pressure was recorded [illegible] several hours after the burn [illegible] levels were subsequently [illegible] hematocrit was 50 on the [illegible] on the next, and 50 again [illegible] day The hopelessly [illegible] (ninety five per cent) [illegible] 3 was admitted in 1935 [illegible] was being used, and he [illegible]

physiologic saline intravenously His blood pressure was 90/60 after admission Subsequent swelling of the arms prevented further determinations but since he was conscious until a few minutes before his death fifteen hours after the injury the circulation in at least the carotid and coronary arteries must have been adequate for the functions of the brain and heart for this relatively long period of time

The above discussion should not be taken to mean that blood volume replacement is not important in certain cases The problem is to decide which patients need it, and if so how much. Unfortunately no practical and safe rule has been forthcoming. Formulas based on body area burned or on the hematocrit determination all are on the side of suggesting too much replacement with the resultant danger of pulmonary edema[15] One would not go far wrong to give every seriously burned adult a liter of blood the first day and half that amount the second day Indications to exceed these amounts would need to be rather definite Whole blood is preferable to plasma, even though hemoconcentration is present The cost of donors fees is only half that of plasma and the red cells administered will serve a good purpose later on when there is a tendency to anemia. Quinby and Cope[16] found that when clinical and experimental burns were treated with whole blood rather than plasma higher hematocrit values (up to 70) were obtained, but no adverse effects on blood pressure pulse, and urinary output were observed Plasma substitutes such as gelatin and dextran might have to be used in the event of a catastrophe with many casualties

Fluid Intake and Urinary Output Most burned patients are very thirsty and take fluids by mouth readily The oral fluids may be given in any palatable form and naturally some items will be salted to taste A seriously burned patient in the Henry Ford Hospital asked for and received the following on the second day Pineapple juice, 200 cc. orange juice 200 cc soup 200 cc., ice cream 150 cc , milk, 400 cc. hot chocolate 200 cc. mixed fruit juice, 200 cc malted milk, 200 cc eggnog 200 cc broth 150 cc tea, 100 cc. and water 1200 cc. There may be danger of "water intoxication" or *salt depletion* when the thirst is quenched by water alone To prevent this, it has been recommended that 3.5 grams (53 grains) of table salt and 1.5 grams (23 grains) of baking soda (sodium bicarbonate) be added to each quart of water

A satisfactory urinary output (*i.e* 500 to 1500 cc) is a good prognostic sign Moderate oliguria is the rule rather than the exception during the first day or two and it should not cause undue concern. If the patient is vomiting or for any other reason cannot take fluids by mouth, parenteral fluid therapy will be necessary Two liters (quarts) of five per cent glucose and one liter (quart) of physiologic saline solution will suffice for most patients If the patient says he is still thirsty more glucose solution can be given

Antibiotics and Other Medication With the current availability of antibiotics it is customary and probably beneficial to administer them to all hospitalized burned patients One injection per day of 300 000 units of procaine penicillin should be adequate Other antibiotics may be substituted if the patient is known to be allergic to penicillin A prophylactic dose of tetanus antitoxin or toxoid is given It has been shown that adrenocortitropic hormone (ACTH) and

cortisone are of no value in the management of the patient with burns Observations at the Massachusetts General Hospital showed that the wounds of burned patients treated with ACTH developed edema and blebs of the same extent, duration, and protein concentration as comparable lesions in nontreated patients [1] Contrary to early claims, ACTH will not make skin homografts take [18]

Treatment During the First Two Weeks

During the waiting period which follows the first three days there is little to be done except for the details of symptomatic treatment A reasonable effort is made to encourage the patient to eat a nutritious diet. Protein is better administered in the form of tempting steaks rather than in the form of synthetic amino acid mixtures There is no evidence that the forcing of food into the stomach through a tube is necessary in the average burned patient in fact, some bad results have been noted with excessive tube feeding.[15] There would be no objection to including additional vitamins in the diet.

The administration of antibiotics should be continued during this period. It should be mentioned that fever and leukocytosis do not indicate infection they are common to all burns of moderate or severe extent. Attention should be paid to the dressings or to the burn crusts if the open-air treatment is being used. Some dressings may be removed from time to time, while others may be reinforced. No change of dressing should be persisted in if there is indication that pain will be produced.

Treatment After Three Weeks

After three weeks in the hospital, one of two circumstances is probably present (1) The burns are healed and the patient is ready for discharge, or (2) he has third degree burns which should be grafted immediately

Spontaneous sloughing of third degree burns usually takes place by the end of three weeks An instance of very early sloughing has been shown in Fig 4 Sloughing is facilitated by the use of moist dressings such as physiologic saline solution or Dakin s solution. Controlled experiments have shown that any aqueous solution is as effective as pyruvic acid in starch paste which has been recommended as a specific for slough removal.[19]

After the third week, most dressings are scheduled as operating room procedures under general anesthesia. The patient is spared the pain of the separation of the dressing from the wound, adherent sloughs can be removed surgically and suitable areas can be covered with skin grafts immediately Parenthetically it may be stated at this time that the method of primary excision of burned areas and immediate skin grafting has been used only sporadically[20] and poor results have been reported.[21]



Fig. 10 Padgett dermatome for the cutting of split-thickness skin grafts.



FIG. 11 Neglected third degree burns of lower extremities in an eight year-old boy showing *condition three months after the injury* Note the *ineffectual attempts with* Reverdin (pinch) grafts. Picture on right shows condition after treatment with wedging casts to *correct contractures and several stages of dermatome skin grafting* There was no residual disability

Skin Grafting Perhaps an explanation for the inclusion of a paragraph on skin grafting in a volume devoted to emergency surgery is indicated The fact *is that for many burned patients prompt* operations for the grafting of skin are life-saving procedures rather than elective measures which can be carried out at any convenient time The Padgett dermatome for the cutting of split thickness skin grafts is probably one of the most valuable surgical instruments to be invented in our generation (Fig. 10) It has permitted an almost miraculous type of skin replacement in patients with large denuded areas by surgeons without special training. It should be considered bad medical practice for a patient to remain longer than three weeks in a hospital where the instrument or its equivalent and a surgeon to operate it is not available Such a rule would have prevented more than two months of suffering of the boy shown in Fig 11

The Padgett dermatome has been improved *recently by Dr Reese who had* added detachable tapes to the drum of the machine and disposable Bard Parker blades which are adjustable for depth by means of shims

The stages of skin grafting in extensive burns may follow each other rapidly With transfusions during and between operations a patient will tolerate grafting procedures every five days Four or five dermatome drums of skin would be considered adequate for a single stage. Not infrequently after one or *more stages of dermatome grafting, some* small unhealed areas remain These should not be allowed to heal by cicatrization, but should be grafted further

making use of small Reverdin (pinch) grafts or stamp grafts cut from dermatome-cut sheets The secret of success in the management of large third degree burns is to graft and graft, and graft again

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65

Management of the Injured Following An Atomic Disaster (Medical and Surgical Plans For Civil Defense)

Consideration of ways and means of meeting the appalling situation which could be created by the detonation of an atomic bomb over an American city requires modification of every normal standard for medical care The circumstances peculiar to an atomic disaster need careful review of even such closely related medical experience as that of combat military medicine, and the civil defense plans of World War II Though every advantage must be taken of such lessons in mass medical care the differences between the basic problems can lead to serious errors in planning. These errors could be fatal to thousands of injured persons unless the medical profession is prepared for these new circumstances

The vast number of casualties which could occur from one atomic burst is the salient difference affecting planning. Though no accurate figures could be assembled for the Hiroshima experience the best available evidence indicated that approximately 80 000 persons were killed immediately or died very soon and that an additional 60 000 to 80 000 were injured. Should such a bomb be exploded in New York State with similar effects, it is assumed there would be some 20 000 to 40 000 litter cases, and from 40 000 to 60 000 walking wounded. It is further assumed that some 27 000 would be burned 13 000 would suffer fractures open wounds and crushing injuries while 12 000 would be subject to moderate to severe shock, and 12 000 be exposed to significant radiation (These figures list casualties with more than one injury under several headings.) It is necessary to plan in the light of such figures for the mere multiplication of the number of injured by the time required for normal surgical procedures clearly indicates the necessity for modification to save time personnel, and supplies if we are to make any significant contribution to the salvage of life and limb

Another overriding consideration in planning for atomic disaster is that this tremendous number of casualties would be injured instantaneously Even the massive bombing raids of World War II permitted adjustment to the rising toll of the injured, allowing for the concentration of physicians and auxiliary per

sonnel according to the directions of a control center which could keep more or less abreast with the problem But the creation of the assumed 12,000 cases of shock in a single instant demands that all personnel would have to move imme diately There would be no time to wait for orders no time for consideration of the best route for movement, no time to wait for a preselected leader Great numbers of volunteers would have to drop their tasks of the moment and move immediately according to a pre determined plan, understood and ac cepted by all.

We must accept the possibility of an attack with insufficient warning for preparation or with no warning at all. Optimism is not permissible in this planning. Though plans for the dissemination of warnings have been developed in de tail and will operate to reduce the num ber of the injured, we must plan for the worst.

This problem differs from military medicine in the necessity for relying upon volunteers professional and nonprofessional, most of whom will be completely unseasoned to the emotional effect of an air raid, of large numbers of casualties or to the organization nec essary for effective operation We shall all be amateurs in dealing with chaos. Should such an attack occur it will be a test of democracy in action, for civil defense against the atomic bomb is everybody's business

Finally facilities for the care of the injured will certainly be inadequate Quite aside from present material short ages and production problems, the in vestment involved in adequate prepara tions for the best possible care would involve expenditures so great as to be impossible for a nation already heavily burdened with taxation It has been a consideration of this necessity that the panels of clinical experts have sternly restricted themselves to the consideration of minimum facilities and procedures

Organization Before Attack*

State. As the medical member of the State Civil Defense Commission, the State Commissioner of Health is the Chief Medical Officer charged with the development of plans before attack, and with the responsibility for central con trol after attack. He has created an Office of Medical Defense in the State Health Department to draft plans in de tail, maintain liaison with the State Of fice of Civil Defense and through the Regional Health Directors, to coordinate the plans of local civil defense jurisdictions. The Regional Health Di rectors are thus the agents of the State Chief Medical Officer carrying out his duty of supervision and coordination throughout the State

Local Under the law a civil De fense Director of a city or county is responsible for all activities within his jurisdiction, before and after attack. However competent his chief Medical Officer a civil Defense Director is not relieved of the responsibility for assuring himself that preparations are being made adequately and that operations are carried out effectively after attack However in practice most Civil Defense Directors are satisfied with medical plans which are approved by the Civil Defense Commission, which in practice means those plans approved by the State Chief Medical Officer through his Regional Health Director It is obvious that complete local autonomy would be

* All explicit statements referring to the law etc. refer to the State of New York and may not apply as explicitly elsewhere

impossible in an operation in which the activities of the medical forces of many communities would have to work together smoothly on short notice.

The major industrial cities of the state have been designated as potential targets Because no city can be self sufficient in the event of an atomic disaster all communities must mobilize to come to the aid of a bombed community In areas not considered potential targets, every effort must be bent to the formation of plans for mobilization to go to the assistance of attacked communities and for the reception of the injured from the scene of attack In addition, blood collection centers must go into action in every community of significant size to collect 20 000 units of blood within the first six hours after a disaster Attention must be focused sharply upon the responsibility of the community to aid a sometimes distant city in the assurance that such plans will best protect all in the event of an attack which is carried out in a manner different from that anticipated In target areas there must be plans for the aid of sister cities as well as for self-help in the event of local disaster No city can reserve medical forces against the possibility of a later attack. These principles must be accepted by every individual who may be involved in medical aid not simply by those responsible for planning the organization

The local Chief Medical Officer in each Civil Defense jurisdiction requires a staff for operations during the present preparatory period and will also require a much larger staff at the time of attack, when every physician within his jurisdiction should be available for assignment to his civil defense post whether at home or in the attacked area. It has been suggested that each local Chief Medical Officer requires at the present time a Blood Service Officer a Personnel Officer for recruiting and training, a Hospital Service Officer and a Public Information Officer In the larger cities designated as target areas, additional suggested personnel are a Nurse Officer attached to the Personnel Office, Supply Officer Medical Transport Officer and a Mortuary Service Officer Though there are many local variations from this pattern these positions describe the volume of work which must be done at the present time if we are to become adequately prepared.

Operations After Attack

The plans for medical operation after attack occurs are perhaps of greatest interest to the physician and nurse who will actually render aid to the injured. The following discussion is a condensation of Information Circular No 10 of the Civil Defense Commission on Emergency Medical Services

In each target city buildings are being selected for Secondary Aid Stations at intervals of approximately two miles in each direction as bases of operation during the first hours after attack Minimum amounts of supplies and equipment are to be stocked in these stations as procurement progresses After attack surviving local physicians nurses dentists veterinarians medical students pharmacists and lay medical aides are to report to their respective Secondary Aid Stations or to the nearest such station which has withstood the blast Where such Secondary Aid Stations are too far apart from the area of destruction to be useful, personnel are to proceed toward the area of destruction carrying with them supplies and equipment from their own stations Other civil defense forces will concentrate upon clearing the streets in the direction of

these stations to permit flow of supplies and personnel from the periphery to the areas where the concentration of wounded is greatest.

Mutual Aid From Other Cities

Since the Emergency Medical Services of any upstate city would be inadequate to treat the assumed number of injured, there are standing orders for the automatic movement of large numbers of trained people from adjacent cities In New York City however it is calculated that the number of uninjured survivors after a singe atomic bomb would be sufficient to care for the injured, so no movement of medical forces from outside the city is planned unless the problem proves too large for local personnel, in which event personnel of surrounding communities will move in along officially designated routes kept clear of refugees and other unauthorized traffic

The bulk of medical supplies and equipment to be assigned to upstate target cities will be stored in Supply and Assignment Depots situated well outside the assumed area of destruction. Each of these depots will be the rallying point for personnel coming from other cities Because this depot will have been in touch with the Secondary Aid Stations brought into operation after attack in order to supply them, the Sector Medical Officer stationed at the Supply and Assignment Depot will be in a position to direct incoming personnel to the Aid Stations where the concentration of work is greatest. As each vehicle returns from a Secondary Aid Station to a Supply and Assignment Depot for further supplies, the driver will bring information concerning requirements in the area of each Secondary Aid Station. As personnel, supplies, and vehicles are dispatched to Aid Stations in areas of concentration of the injured, the Secondary Aid Station will set up as routes are cleared, First Aid Stations closer to the center of the area of destruction As the Secondary Aid Station continues in operation and gives aid to the injured in its immediate area and arranges for their transportation to the rear it is anticipated that its functions will change from giving primary aid to the injured to a clearing station for the injured from its daughter First Aid Stations

First Aid Stations

Each First Aid Station is to be staffed by a physician assisted by several dentists veterinarians, or medical students nurses, and a larger number of Medical Aides men or women trained in first aid to the injured. Record clerks and messengers will complete the complement of such a Station. From each First Aid Station, Medical Aides will fan out with stretchers to pick up the wounded and bring them to the Station. Because of the limitations of strength of the Medical Aides it will be necessary to set up First Aid Stations at intervals of 180 to 460 meters (200 to 500 yards) ringing the area of destruction as the pattern of wreckage and of the concentration of the wounded may indicate

Functions of Medical Aides Because of the necessity of utilizing inexperienced and necessarily insufficiently trained volunteer lay personnel in the field, Medical Aides must be instructed to concentrate upon transportation of the injured to the First Aid Stations with a minimum of manipulation in the field. Their functions will be

1 Stop bleeding.
2. Apply splints for transport.
3 Cover wounds and burns.
4 Give morphine as authorized by a physician.

5 Tag the injured to indicate medical aid given in the field, and location of the moment of explosion.

6 Transport the injured.

7 Direct the less seriously injured who are able to walk to the rearward stations

Medical Aides can be expected to do little more than move the seriously injured without seriously impairing their chances of survival. Because of fires to be expected in the area of destruction, as well as the great number of injured in some areas time-consuming operations such as administration of plasma in the field, artificial respiration, and extensive dressings, could not be carried out by the Medical Aide even if his training were sufficient to insure successful rendering of such services

Functions of the First Aid Station Here as in the field, emphasis must be upon minimum treatment and rapid movement of the injured rearward. Time-consuming procedures would only lead to congestion which would limit the number of injured which could be handled by any given station The physician in such a station would direct his personnel for the most part, rather than attempt to do dressings, and apply splints Perhaps he would limit himself to tying off seriously bleeding vessels and the insertion of the needle of a blood substitute outfit in an especially difficult vein In the First Aid Station functions would be largely limited to

1 Control of hemorrhage and asphyxia developing as a complication of other injuries

2 Administration of blood or blood substitutes

3 Dressing of wounds

4 Administration of morphine

5 Adjustment or application of splints

6 Administration of antibiotics when transportation to rearward stations is unduly delayed

7 Tagging of patients concerning place where found, treatment given and degree of urgency of further treatment.

FLOW OF THE INJURED

From the First Aid Station the injured would be transported by vehicle to the parent Secondary Aid Station, from which further supplies are secured. At the Secondary Aid Station the wounded would be again inspected as to urgency and classified as

1 Urgently requiring supportive treatment such as blood, blood substitutes, morphine, or reparative surgery

2 Suitable for immediate transport to an emergency hospital.

3 Suitable for long transportation to hospitals in distant cities after wounds are dressed.

4 Suitable for discharge to home or reception center after treatment.

At the Secondary Aid Stations messages would be received from the Supply and Assignment Depot concerning the location of improvised Emergency Hospitals which had been set up in the area Thus the Secondary Aid Stations could direct the more seriously injured to nearby Improvised Emergency Hospitals and the less urgent to the more distant. Cases in relatively good condition would be sent to Hospital Trains for transportation to institutions in distant cities

IMPROVISED EMERGENCY HOSPITALS

It is evident that many of the seriously injured will urgently require more extensive treatment than could be attempted in an Aid Station For these cases Improvised Emergency Hospitals must be set up in schools hotels, and the like as near as possible to the area

of destruction Even in New York City where the permanent hospital bed capacity could conceivably be expanded to a number sufficient to provide care for those injured by one atomic air burst, disruption of transportation and traffic congestion may be so great as to prevent utilization of hospitals in distant boroughs for many hours or a day or two The problems involved in rapidly setting up many such installations will require stocking large quantities of disposable presterilized supplies Consequently provision must be made for antiseptic technics with heavy reliance upon antibiotic therapy for nondeferable surgical procedures So far as per space, every effort must be directed to- mitted by the number of bombings, the numbers of casualties and available bed ward early transfer of patients from Improvised Emergency Hospitals to permanent hospital installations, sometimes at considerable distances from the scene of attack. Though it will be possible during this period of transfer to concentrate certain types of cases in hospitals devoted to special categories of the injured, it must be anticipated that such complex sorting could not be accomplished for days after attack.

The staffing of Improvised Emergency Hospitals will require detailed planning by every hospital staff of institutions with more than 100 beds It must be borne in mind, however that staffing of Aid Stations must take priority during the first forty-eight hours for failure to save lives in the field would render most of the Improvised Emergency Hospitals unnecessary

Blood Program

It is evident that great numbers of the injured would urgently require blood replacement in the early hours following such a disaster and that the need for blood would continue at a very high level for many weeks. The quantities required and the cost of such blood derivatives as fluid or dried plasma or serum albumin preclude stocking adequate amounts of these materials Blood substitutes such as dextran and periston are to be stocked in sufficient quantities near target areas to meet the demands of at least the first hours of the emergency Plans have been made for the rapid dispatch of existing stocks of whole blood to the disaster areas, but problems of blood grouping and cross-matching recipients make it evident that only in permanent hospital installations will group-specific blood be utilizable during the first few days

Accordingly plans have been completed and preparations are under way for blood collection in every institution in the State where this can be carried out. Upon the assumption that the population in nonattacked areas will respond in great numbers, typing can be carried out at the time and 20 000 units of whole blood be collected by the sixth hour after disaster During the first forty-eight hours only type O blood is to be drawn and until blood-typing facilities are set up in the disaster area, type O will be administered without cross matching and without regard to the Rh factor Stocks of blood typing serum are being set up for the period when group-specific blood will be used, when every microscope will be required for grouping and cross matching

EMERGENCY TREATMENT OF MAJOR OPEN WOUNDS BLAST AND CRUSH INJURIES

The following is condensed from the report of the surgery panel, chairman, Dr Charles G Child.

A consideration of major open wounds, blast and crush injuries is closely related to the total field covered by all the other panels. The report of this panel is restricted to the local therapy of wounds at the site of the injury at First Aid Stations and at Secondary Aid Stations

When dealing with staggering numbers of injured individuals, two guiding principles must be followed. The first of these is to bring professional medical judgment to bear on the care of the injured at the earliest possible moment and thereafter to maintain a continuity of treatment. This involves taking medical aid to the site of disaster in the form of first aid treatment, preparing patients for transport to more definitive treatment facilities and providing the most expeditious transport of patients that may be possible The second principle is the establishment of a rank order of priority to be assigned to the care of various types of injuries In general, injuries should be considered in the following order of priority for treatment

1 Hemorrhage
2 Chest wounds and asphyxia
3 Abdominal wounds
4 Crush and blast injuries
5 Head and spine injuries

Successful application of the first principle may depend to a great extent upon the efficiency of the Medical Officer in the First Aid Station in establishing the above priorities for care and in sorting patients accordingly

Disaster Area After the location of their First Aid Station is determined, Medical Aides will proceed further into the area of disaster render first aid and return injured to the First Aid Station When working out from a First Aid Station Medical Aides will give only sufficient treatment to make patients transportable. This includes application of field dressings to prevent additional contamination and to control hemorrhage Use of a tourniquet should be discouraged as much as possible To carry out these functions it would be necessary for such workers to carry a minimum supply of bandages and dressings Precautions to be observed in transport include the avoidance of additional trauma Patients should be rolled onto the stretcher where this is possible Unconscious patients and those with head and back injuries should be carried in a face down position (Use of morphine in the area of disaster as well as problems related to fractures burns shock and embarrassed respiration are covered in other chapters)

First Aid Station The physician in charge of a First Aid Station assumes many responsibilities He must sort the seriously injured from those with trivial wounds He must be able to direct his staff in the care of patients in so far as their training and ability permit He should be able to recognize when operative control of hemorrhage or tracheal obstruction may be lifesaving He must appreciate that one of his primary responsibilities is to get as many patients as possible in shape for transportation in the shortest possible time He must ever bear in mind that the sooner a patient can receive a definitive therapy under hospital auspices the better the chances of survival In general the physician will be required to insert airways perform tracheotomies pack sucking wounds of the chest, install flutter valves in tension pneumothorax, pack and apply pressure dressings in the more extensive open wounds and apply suture ligatures to control bleeding However the exigen-

cies of the situation may require that the physician be prepared to delegate most of the work he would ordinarily expect to do himself so that he can supervise care of several critically injured patients

In evaluating the status of patients those with blast, crush and radiation injuries which later might prove to be serious should not be permitted to aid in evacuating the injured or to proceed as ambulatory patients

Other workers in the First Aid Stations and for that matter in all emergency medical facilities, may be expected to possess varying degrees of knowledge and technical skills in handling of injured patients For instance nurses dentists, veterinarians nurses aides, and medical aides will have to be prepared to receive either general or specific directions depending upon their capabilities They may be expected to carry out many treatment procedures including suturing, dressings, control of hemorrhage, relief of asphyxia, and parenteral administration of fluids morphine, and antibiotics

Medical Supplies In order to simplify the problems of procurement and supply it is necessary to keep recommendations regarding dressings, instruments, solutions, antibiotics, and supplemental equipment to a minimum both in amount and variety The cost of masks, for instance makes it practicable to stock them for use wherever surgery is to be done but it may be necessary to dispense with gloves and gowns in the First Aid Station. Soap and water or aqueous benzylkonium chloride (tinted 1 1000) may be used for resterilization of instruments and for operator s hands and skin surfaces Again, in order to supplement the supply of conventional suture material in case supplies run short #8 commercial black cotton thread might be included in the list of instruments and supplies.

No plans are in effect at this time to give either tetanus antitoxin or booster inoculations of tetanus toxoid routinely to patients injured in atomic attack. It is recommended that all persons receive an adequate active immunization with alum precipitated tetanus toxoid *during* the coming months for protection against tetanus

Secondary Aid Station Except under circumstances in which a Secondary Aid Station takes on the functions of an Improvised Emergency Hospital, its primary function would be to continue the care of the injured while they await transport to facilities *providing definitive* treatment Treatment would therefore be similar to that given in First Aid Stations Delay in transport might require reinforcement of dressings further control of hemorrhage maintenance of airways further treatment of chest, abdominal and crushing wounds Long delays in transport of patients might require repeated administration of antibiotic and other parenteral therapy In addition, general supportive measures such as parenteral fluids should be given when it seems likely that major surgery requiring general anesthesia will become necessary

Improvised and Permanent Hospitals Problems relating to supply staffing, and treatment in Improvised Emergency Hospitals and Permanent Hospitals will require further consideration In view of the probability that many patients needing care cannot be hospitalized for optimum periods of time Secondary Aid Stations and some First Aid Stations will have to be kept

in operation for several days or weeks to provide outpatient type of treatment. Large numbers of patients with traumatic injuries burns and radiation illness who under normal conditions would be hospitalized, may have to be cared for on an outpatient basis

Fluid Therapy in Shock and Burns

The number of cases of shock trauma burns and radiation sickness will demand amounts of whole blood which will exceed usual resources Blood derivatives and substitutes will be required to save lives in early hours after attack and to prepare the patient for transportation to safety medical care and definitive surgery The type of fluid therapy will depend on the time personnel, and supplies available as well as the nature of the injury

Therapeutic Agents: The advantages and disadvantages of whole blood, blood derivatives and electrolyte therapy are as follows

Whole blood is the most valuable single therapeutic agent. As a first aid measure, blood will be needed in hemorrhage and burns With the latter administration may be delayed twenty four to forty-eight hours, if a substitute is available

Blood derivatives include frozen and dried plasma, fluid plasma serum albumin and the "stable plasma protein solution" of Cohn All are at least five to six times more expensive to produce than blood substitutes

Frozen and dried plasma could be used as a life saving measure However cost and the risk of homologous serum jaundice limit its practicability

Fluid plasma stored at room temperature has been given several clinical trials which suggest that it is free of the virus of homologous serum jaundice Problems of preparation and storage, as well as cost make this material difficult to procure in quantity

Serum albumin cannot be obtained in sufficient quantities to permit consideration because of very high cost and limitations of supply

Stable plasma protein solution must be excluded for the same reasons as serum albumin. Adequate clinical study is required before any decision is made on its value as a blood substitute

Blood substitutes include gelatin dextran and periston (polyvinyl pyrollidone) which are less expensive than the above mentioned blood derivatives and can be produced in larger amounts commercially However it is doubtful if any of these three compounds will be produced in quantities sufficient to meet the estimated needs for Civil defense within a year It is believed that all three of these blood substitutes will be produced for about the same price

Gelatin of large molecular weight is suitable for intravenous administration under conditions permitting the semi solid material to be warmed into a fluid state However this excludes its use under emergency field conditions Gelatin solutions of smaller molecular weight are fluid at ordinary temperatures but are excreted more rapidly in the urine Further clinical trial of these newer gelatins is needed. It is probable that they can be used to treat shock and sustain adequate blood volumes until other agents are given Gelatin increases the sedimentation rate and may cause formation of rouleaux of erythrocytes which can interfere with blood typing. The latter effect is reduced in typing and cross-matching of such blood by the

addition of one drop of one per cent glycine in physiologic saline solution to the test mixture

Dextran is a polysaccharide produced by one of several saprophytic bacteria growing in media containing glucose The molecular weight of the polysaccharide varies with the micro-organism and conditions of cultivation Subsequent treatment will reduce the size of the dextran molecule to conform with that of serum proteins It is excreted in the urine but plasma volume can be maintained for twenty four hours. It has received extensive clinical trial in Sweden and in several medical centers in this country It is considered equal to, or better than, gelatin Reactions of an allergic type have occurred in patients, suggesting that there is an antigenic substance in the dextran solutions the nature of which has not been defined. Immunologic relations between dextran, the saprophytic bacteria used to produce it, and certain types of the pneumococcus have been noted It increases sedimentation rate but does not produce significant changes in the level of the blood electrolytes or interfere with blood grouping or cross-matching More information is needed on the fate of dextran retained in the body Despite this, dextran holds great promise as a blood substitute and should be stockpiled.

Periston is a polyvinyl pyrollidone, a synthetic polymer of acetylene, the molecular weight of which can be rather readily controlled. It can be produced in large amounts. It was given extensive clinical trial in Germany during World War II but lack of adequate information from German sources requires further study There is evidence of storage pathology and the metabolism of unexcreted periston has not been determined. If clinical trial proves periston to be as effective as dextran, it will probably be the blood substitute of choice because of the ease of production.

Oral electrolyte therapy with hypotonic solutions of sodium chloride and sodium bicarbonate (or sodium citrate when available) is recommended for the maintenance of adequate blood electrolytes in conscious cases of burns This solution is made by adding one teaspoonful of salt and one half teaspoonful of baking soda to each quart of water

Intravenous physiologic saline solution alone or with five per cent glucose can be given to sustain the blood volume until more adequate fluid therapy is available

While *nor-adrenaline* is very valuable in the treatment of surgical shock, it requires such continual supervision that it is excluded from use in field emergency posts but can be employed in hospitals

The use of the enzyme *hyaluronidase* as an accelerator of absorption of subcutaneously administered fluids is of questionable value because of the possibility of bacterial contamination in the presence of potentially reduced cellular defenses.

Regimen of Therapy DISASTER AREA No fluids are given

FIRST AID STATIONS Speed of evacuation has priority over fluid therapy Plasma substitutes may be given if the patient will not otherwise survive transportation to the next station

SECONDARY AID STATIONS Hypotonic solutions of sodium chloride and sodium bicarbonate are given to all conscious cases of burns as thirst (E...) requires Burns covering fifteen per cent of the body surfaces or less may require

only oral therapy Only oral fluids are permitted until the edema at the site of the burn subsides

Blood substitutes physiological saline solutions with or without five per cent glucose can be given in order to save life or to permit the patient to be transported to the hospital Only physicians properly trained dentists veterinarians medical students nurses and certain medical aides can give intravenous fluids Give intravenous fluids in amounts sufficient to maintain the blood pressure between 85 and 100 mm of mercury

Improvised Emergency Hospital Oral electrolyte therapy of conscious cases of burns and electrolyte and glucose therapy already started are continued as necessary until blood derivatives substitutes and whole blood are available Properly experienced nurses and nonprofessional personnel can give all forms of intravenous fluids The prescription and administration of whole blood should be under the supervision of a physician triage officer at each emergency and permanent hospital

There is a very important place for intramarrow administration of fluids particularly in shock, in extensive burns and other injuries when the intravenous route cannot be used or when a vein cut down is necessary and urgency or expediency contraindicates this procedure Irritating or sclerosing solutions should not be given into the marrow Hazards of intraosseous infection, special equipment, and the limitations of numbers of physicians qualified to apply this procedure restrict for the most part its use to hospitals

THERAPY OF SHOCK IN SPECIFIC INJURIES

The nature of the injury rather than the immediate clinical status determines the necessity for the treatment of shock. The following injuries may require fluids

1 Abdominal
2 Chest (including blast)
3 Major wounds of extremities
4 Skull wounds
5 Crush injuries
6 Burns

Abdominal Wounds All will have lost some blood. At least one preoperative transfusion is indicated Enough blood should be given to those in clinical shock to raise their blood pressure to 85 or above If hematocrit is available raise to 35 by transfusion. If 1500 cc (3 pints) of whole blood have been given and the blood pressure fails to rise to 85 or the hematocrit to 35 it must be assumed that active bleeding is present and the patient should be transferred to surgery immediately irrespective of any existing ominous clinical condition

Abdominal operations should be performed within six to eight hours after injury If surgery has to be deferred beyond this period of time a slow maintenance infusion of glucose in distilled water should be used as long as blood pressure remains above 85 If the latter should start to fall, fluid replacement therapy should be guided by blood studies If there appears to be an adequate or elevated level of hematocrit, red blood cells or hemoglobin, sufficient plasma should be given to maintain the blood pressure, but if there is evidence of anemia further amounts of whole blood should be used

Extremity A maintenance of the previously mentioned base level of pressures should be obtained by the use of whole blood prior to transfer to surgery

Chest Delay surgery and anesthesia until there is good respiratory exchange through a clear airway Overzealous administration of parenteral fluids may result in fatal pulmonary edema.

Skull Wounds. Fluid administration of whole blood should be given in sufficient quantity to establish an adequate blood pressure If the blood pressure is already adequate or elevated fluids should be withheld.

Burns. The flash burns apparently because of their charring effect, presumably will not offer as great a problem in fluid administration as the thermal burn Both blood and blood substitutes are necessary for the latter

More specific information and definitive treatment of these various injuries are discussed in other chapters of this book under their appropriate title

* * *

This chapter is modified from the Symposium on Plans for Medical Defense which appeared in HEALTH NEWS June 1951 The specialist panels were appointed by the Emergency Medical Preparedness Committee of the Medical Society of the State of New York, Dr John J Masterson Chairman

CORTEZ F ENLOE JR M.D., AND FRANZ K BAUER M D

66

Emergency Surgery and the Air Raid Casualty

No discussion of emergency surgery can be considered complete without reference to emergency surgical care during air raids This subject cannot be ignored because under conditions of an air raid many of the surgical emergencies referred to in this book will undoubtedly be encountered At best, such contingencies must be anticipated

The air raid does not inflict any surgical casualty not seen in daily practice The attacks on civilian populations do not produce injuries requiring peculiar surgical procedure What does occur however is that there are more emergency cases than can ordinarily be cared for there will be more unskilled individuals attempting surgical procedures and every type of trauma imaginable will be encountered

It is to orient the student of emergency surgery to the general nature of the type of casualty with which he will be confronted that this chapter has been included It is hoped that a study of the lessons learned at great cost about the nature of air raid casualties will prompt a clearer realization that the circumstance of an air raid requires a demonstration of all the surgical skills described in this book.

Every physician should have written in his air raid hat the four following admonitions

1 Treat first those who can be helped most.

2 Dismiss those you have treated

3 Do not waste time on those whose injuries are minor or so serious that the hope of survival is slight.

4 Be on the alert for the unexpected.

From seventy to eighty per cent of the injuries encountered by the physician will be of a thermal or mechanical nature They will not be peculiar to the atomic bomb since in emergency surgical care the injuries of atomic radiation are in themselves of little concern. If one examines the casualty records of the high explosive and fire-bomb raids on German cities and compares them with the casualty experience in the atomic bomb raids on Hiroshima and Nagasaki it is quickly apparent that for the person on the target it makes little difference whether the weapon is atomic or T.N T The types of injury to be expected are pretty much the same Excluding the radiation effects which may affect twenty per cent of the casualties the surgeon on emergency air raid service should acquaint himself with restora-

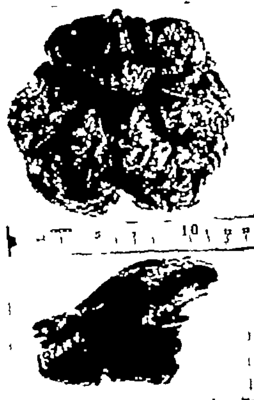


FIG. 1 Air raid casualty Specimen of brain and lungs of a heat death victim. Organs dry and hard. Note scale in centimeters.

tive technics resulting from the following conditions

1 External injury resulting from
   (a) Burial under rubble and debris.
   (b) Objects flying at extreme velocity
   (c) Explosions, immersion, scalding, chemical burns, poisoning, and by-products of exploded bombs.
   (d) Fire (direct contact)
   (e) Lack of proper serological prophylaxis.
2 Internal injury resulting from
   (a) Carbon monoxide inhalation in air raid shelters (occasionally occurring during rescue work)
   (b) Effect of heat through conduction and thermal radiation of extremely high temperatures
   (c) Overheating for a long period, at temperatures that can be tolerated normally for a short time only
   (d) Dust inhalations blocking of the upper respiratory passages, with damage to the small bronchi and alveoli
   (e) Psychosomatic collapse in the critically ill.
   (f) Blast injuries in which internal injuries may or may not be masked by external trauma

EXTERNAL INJURIES

Mechanical Injuries Injury and death from mechanical causes head the list of casualties Direct hits by flying debris burial under rubble from collapsed buildings, and burns, all conditions which the physician will recognize as being closely associated with shock, may be expected to form the principal category of injuries Even a moderately substantial shelter will protect a person from such bomb effects

THERMAL INJURIES For those sheltered from such mechanical injuries however there remains the greater peril, fire. In many respects, the atomic bomb is a tremendous incendiary Although blast is responsible for most of the destruction caused by an atomic bomb the Atomic Energy Commission has stated that "thermal radiation can make a significant contribution to the total damage by producing skin burns in living organisms and, to a lesser extent, by igniting combustible structures and initiating fires " Whereas in a high-explosive raid (the type carried out on European cities and the type to which this country is

apparently almost immune) mechanical injuries would outnumber deaths, in an atomic bomb attack it is expected that the effects of heat and carbon monoxide would cause more deaths than injuries The crowded conditions of American cities the height of buildings, the age of dwellings, the type of construction—all these are factors that would influence the spread of fire following an atomic attack



Fig Air raid casualty Specimen of lungs and heart in a case of heat death Organs shrunk to a fraction of their normal size Hard consistency

An intimate knowledge of the emergency treatment of the injuries induced by fire *e g* burns, inhalation of super heated air is the most important professional asset the air raid surgeon can bring to his task

The experience of protecting people from a fire in peacetime provides little preparation for what happens in the type of fires that follow atomic bombing In the first place in peacetime fires occur singly There is very little danger of persons being buried in the rubble. There is almost no problem of super heated air and there is not the great chaos that occurs when an entire area of a city is in flames This difference becomes dramatically apparent when one reflects that in a peacetime fire the family is usually standing across the street watching their belongings being thrown out of the window whereas in an atomic conflagration they are sealed in the cellar to which they have retreated

To reduce the number of casualties in an air raid it is essential that the surgeon be prepared to treat hundreds of people who are suffering the effects of heat, including the effect of intense heat of short duration from conduction or thermal radiation, with the production of burns and the effects of high temperature over long periods The latter may not result in skin damage, but it usually causes the same syndrome as heat stroke

INTERNAL INJURIES

Heat Stroke The time at which injury from heat occurs varies with several factors, such as the humidity of the air the cessation of sweat production and the degree and duration of heat to which the body has been exposed In humid air heat stroke may occur in a temperature of 60 C and not necessarily be associated with subjective complaints This factor accounted for the many persons found dead in rooms from which escape would have been possible and found in a position not suggestive of agony before death

Effects of Intense Heat One of the fire raids on which we have the most complete data was made on Hamburg Germany in the summer of 1943 It is

well to remember that during this raid 60 000 people were killed, almost as many as were killed in the atomic bomb raid on Hiroshima Police engineers in Hamburg estimated that temperatures in the burning city blocks went as high as 1472 F (800 C) Hundreds of persons were seen leaving shelters after the heat became unbearable They ran into the streets and were seen to collapse very slowly as if from utter exhaustion Many thus felled were found naked. Two explanations have been offered for this phenomenon The first is that flames spurted across the avenue with the speed of a tornado and consumed the victim's clothing, singeing the skin the other is that the intense heat disintegrated the clothes without actual burning Shoes were usually the only covering left on the bodies When the bodies were recovered, they were not burned to ashes, but the body tissue was dry and shrunken and resembled that of a mummy In many cases the intense heat caused the skin to burst and retract over the elbows the scalp and the orbit Autopsies performed on a large number of these bodies showed venous stasis with increased permeability of the small blood vessels, as well as damage to the chromatin and to practically all the cells of the abdominal organs and the lungs This result has been attributed to exposure to and inhalation of superheated air

Beyond the local effects of heat, over burdening of the heat-regulating mechanism of the body must also be considered. Hindrance of the heat exchange between the body and the external atmosphere may be the causative factor Many air raid shelters closed off by rubble produced an atmosphere intolerable to the occupants Heat damage was noted in members of rescue squads who entered basement shelters where proper ventilation had been cut off for some time Escape from overheated shelters has its hazards too In escaping through burning city blocks the danger is chiefly from radiated heat. The inhalation of hot air may cause severe damage to the respiratory passages, such as ulcerous necrosis of the mucous membranes Whether this is a separate entity or part of the whole picture of injury and death is as yet undetermined.

Carbon Monoxide Poisoning It should be kept in mind that any inhalation of dangerous gases or by-products of fire must also be considered. Carbon monoxide poisoning is one of the chief types of injuries that the emergency surgeon may expect to encounter It is the primary and characteristic cause of injury and death from the air in public air raid shelters, and improvised home shelters. Carbon monoxide casualties may always be expected in flaming buildings where exits have been blocked

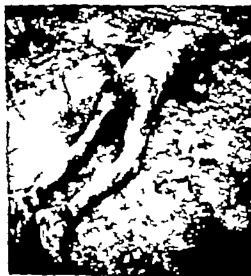


FIG. 3 Air raid casualty Another victim found in the streets of Hamburg after the incendiary raid of July 27/28 1943 effect of heat. Note absence of clothing and presence of shoes.

by rubble indicating the imperative need for adequate exits

In addition to the obvious trauma—the fracture that has to be reduced, the hemorrhage stopped, or the wound to be closed—carbon monoxide poisoning must be assumed in any person arriving at emergency surgery from a burning building or collapsed shelter

Certainly the surgeon should not set up shop in a basement or in any place without ready ingress and egress Too many people think about basements when someone mentions air raids One cannot glibly endorse this general attitude that the basement of every dwelling affords relative safety It may afford safety from blast, but if the building catches fire and as we have said, fire is the main cause of atomic bomb damage the cellar becomes but a tomb It is interesting to note that in one fire raid on the city of Wesermunde 175 out of 210 corpses recovered presented a picture of acute carbon monoxide poisoning In Hamburg, it has been conservatively estimated that seventy per cent of all casualties not resulting from mechanical injury or burns were induced by carbon monoxide.



Fig. 4 Air raid casualty Body of a young woman heat death. Induration of skin and underlying tissues.

A concentration of 0.5 per cent carbon monoxide in the air may cause death after one hour's exposure A concentration of even 0 1 per cent may still produce symptoms of intoxication Thus, when it is realized that the fumes from ordinary fires are said to contain three per cent carbon monoxide, coal gas six per cent, and gas from high explosive bombs sixty or seventy per cent, it is not strange that carbon monoxide poisoning must be considered a prime cause of death and injury Characteristic of carbon monoxide deaths in air raid shelters were the peaceful positions of the bodies found in one shelter positions suggestive of complete lack of apprehension of imminent danger Recognition of the importance of carbon monoxide poisoning indicates the urgent need for laboratory and clinical research on the prevention and treatment of carbon monoxide intoxication.

It is the duty of every surgeon to acquire a working knowledge of the treatment of carbon monoxide poisoning and to understand thoroughly how the presence of this complication will influence the outcome of his surgical procedures

Air Blast Injuries Injury from air blast itself as distinguished from injury caused by fragments carried by the blast, may be expected to be encountered relatively infrequently It will affect only those people who are in the open at the time the bomb explodes However the intensity of an atomic bomb explosion is so great that persons close enough to be damaged by the air blast also will probably be consumed by the ball of fire

that will extend beyond the critical area where the blast itself can cause physical damage to a human being Some such blast injury may be experienced by persons trapped in hallways or near the entrance to open manholes or other man-made caves from which the blast wave cannot escape. In such instances, the pressure wave is compressed and may be expected to result in such injuries to the ear as perforated drum membranes, damage to Corti's organs, and inner ear deafness and also cause tearing of lung tissue, resulting in air embolism and in conjunctival and retinal hemorrhages. Shielding of almost any kind will afford a great measure of protection from air blast.



FIG. 5 Air raid casualty Victim of heat found lying on his abdomen but rolled over on his back to show intact skin on chest and abdomen. Genitalia greatly swollen. Note extensive carbonization.

Blockage of Upper Respiratory Passages The inhalation of dust is seldom a cause of death, yet it is a casualty producing factor which the surgeon must take into consideration. After air raids, there have been some cases in which the patient's upper respiratory passages down through the larynx were blocked with dust. Strangely only small amounts of dust were found in the alveoli in such patients. Therefore it is held that the inhalation of extremely dense concentrations of dust does not interfere with the gas exchange in the alveoli but results in a physical blockage of the air passages The afflicted persons literally "drown in dust."

The presence of such dust masses must be suspected in every patient exhibiting the signs of asphyxia

Drowning In considering the health and safety aspects of air raid shelters, the physician should not overlook the possibility of death by immersion. The breaking of water mains as a result of the blast of an atomic bomb and the collapse of buildings, would permit water to seep into shelters and basements drowning the occupants

Hysteria Contrary to expectations it has not been demonstrated that air attacks on civilian population increase the incidence of psychiatric disorders There is no evidence to support an occasionally voiced prognostication that either organic neurologic diseases or psychiatric disorders can be attributed to or even conditioned by air attacks To be sure the physician must anticipate some fleeting reaction symptoms in the nature of neurohysteria after a severely damaging attack, but that these may be of an enduring and psychotic nature is dubious and has not been proved by experience thus far Air raids may slightly influence the course of affective emotional disorders and increase tension states anxieties and exhaustive states among the people, but this may not be expected to occur to an alarming degree It is questionable therefore, whether such protective measures as the establishment of psychiatric first-aid stations are necessary As a hypothesis it



FIG. 6. Air raid casualties. Scene confronting rescue workers entering air raid shelter some time after a raid. Victims succumbed to carbon monoxide asphyxiation.

appears sound, but experience has shown that it is a waste of time

More pertinent to the problem of the surgeon is an awareness of increased likelihood of the psychosomatic collapse of the critically ill This, of course has direct bearing on the outcome of the surgical procedures

The air raid surgeon must therefore be on the alert to detect symptoms of the following, even before beginning surgical procedure since these factors would vitally affect the outcome of surgery

1 Heat stroke

2 Hysteria or psychosomatic shock

3 Shock from loss of blood or trauma.

4 Carbon monoxide poisoning

5 Blockage of the upper respiratory tract.

6 Blast or pressure injuries of an internal nature

The foregoing suggests the type of air raid casualties which the air raid surgeon may expect It is his duty and responsibility to take such measures as he can to reduce the effects of such appalling injuries Civil defense is here to stay It is now a fact in our lives It is not transient but permanent and the medical profession stands first in the line of those who can reduce the effect of enemy attacks on our countrymen. Our job is not only to treat the wounded and to rehabilitate them so that the country can carry on but also to ferret out those places in our communities where our scientific knowledge and professional guidance can lead to increased protection of the individual in order that fewer will need treatment when catastrophe descends upon us.

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For first hand accounts of surgical experiences in the treatment of air raid casualties the reader is referred to the following documents reposing in The National Archives World War Section War Records Branch, Washington D C Reproductions are available on payment of a small charge

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The Radiation Syndrome—Its Diagnosis and Treatment

THE clinical picture of signs and symptoms which follow the exposure of an individual to whole body ionizing radiation is called the radiation syndrome These signs and symptoms do not differ greatly from those induced by other types of injury and occur in a definite specific pattern The initial state of primary shock accompanied by nausea and vomiting is succeeded by a latent or incubation period of varying length, followed in turn by nonspecific toxicity infection hemorrhage anemia and finally a state of abnormal nutrition and metabolism It is obvious that considerable overlapping of these specific entities can and does occur producing a remarkable variety of clinical states following a single exposure on a specific occasion As one reviews these signs and symptoms a remarkable similarity between them and those observed following certain disease states and marked exposures to toxic material can be noted. However it is unusual to find the complete pattern of clinical events following a single disease or noxious exposure

Correct therapy of the radiation syndrome demands an early recognition of a possibly lethal exposure so that therapeutic measures and procedures can be instituted prior to the development of the first symptoms To date, therapeutic methods which have been instituted after the latent period has elapsed have invariably resulted in complete failure To appreciate more fully the remarkable complexity of the radiation syndrome it is important to review what is known concerning possible mechanisms by which the injury is produced, that series of physiological events which follows exposure as well as the possible role of complicating factors such as infection and the like all of which combine to produce a clinical entity of the radiation syndrome

A simple concept of the radiation syndrome is presented in Table I For purposes of simplification exposure deals with an individual receiving lethal dosages of ionizing radiation alone and does not consider the complicating issues which arise with simultaneous injuries due to burns or trauma Exposure of all the cells of the body to a beam of ionizing radiation causes a primary effect within the tissue which is physical in nature The total amount of radiation delivered can be measured accurately by specific instrumentation but nonetheless is completely insensible to the indi

TABLE 1

THE RADIATION SYNDROME

Radiation Effect	*Type*	*Reaction*
Primary	Physical	Ionization (Measurable)
+		
Secondary	Chemical	Altered Biochemical Reactions
	Biological	Sum of Altered Biochemical Reactions
+		
Complicating Factors		Infection and Altered Immune Processes
		Toxins or Abnormal Detoxification
		Hemorrhage
		Endocrine Imbalances
=		
Radiation Syndrome		Altered Metabolism and Nutrition
		Anemia
		Altered Fluid and Electrolyte Balances

vidual. In simple fashion one is able to calculate the total amount of physical energy that can be absorbed by the human body receiving a lethal amount of radiation. Calculated in terms of units of radiation (roentgens) one notes that an individual receiving a lethal dose of radiation of approximately 500 r (roentgens) has had ionization of approximately one atom in one hundred million total atoms in his tissues This amount is sufficient to produce a definite lethal outcome If only one of a hundred million atoms is affected and thereby produces a lethal result, it is obvious that the change in terms of measurable energy must be remarkably small A dose of 500 r would produce a temperature rise of approximately 0 001° C within the whole body Therefore, radiation injury cannot be ascribed to temperature rises or other diffuse energy absorption but rather to discrete bombardment leading to destruction of highly organized molecules or tissue structures. This may occur either through one or more direct hits by gamma rays or beta or alpha particles on a large molecule such as that of an enzyme, breaking it irreparably or it may occur secondary to a phenomenon of ionization. In the latter instance the ray or particle may remove one or more electrons from a simple atom or molecule in the tissue fluid, thereby creating a strong ion whose force field is capable of breaking down irreversibly the neighboring complex tissue molecules or structures If this electron is thrown out of its path, the atom may react in a normal chemical or physiological manner If this atom is present within an important enzyme system, it is possible that this system will not function efficiently In turn if sufficient atoms are changed within the enzyme system normal function may be completely lost. This would lead to a definite *secondary effect* a change in *chemical reaction*. A series of chemical reactions if sufficiently altered, could produce a definite biological reaction which would ultimately produce death or serious disability of the exposed individual. If one adds to this group of biological reactions the effect of the various complicating factors such as infec

tion arising due to depression of the defense mechanism (depression of leukocytes and immune processes to critical levels) the appearance of toxins, abnormal metabolites, or possible altered detoxification mechanisms, the appearance of hemorrhage due to failure in coagulation mechanisms the undoubted presence of some form of endocrine imbalance plus the expected altered metabolism and nutrition anemia, and altered fluid and electrolyte balance a physiologic picture results which is not easy to study or to analyze

From the rather tremendous literature on this subject it is possible to arrive at certain generalizations which summarize what is known concerning the biologic effects of ionizing radiation. These can be listed quite briefly The types of physiological and clinical effects are multiple and varied but are all non specific and not characteristic of radiation alone All types of radiation, whether gamma rays, beta or alpha particles, or neutrons produce the same qualitative effect, but vary in magnitude with the ionization characteristic of the ray or particle So far as is known all effects of ionizing radiation are injurious to cells and tissues of an individual The amounts of energy required to produce these injurious reactions are so small as to indicate that some type of multiplication of effect develops following the physical change which in turn, leads to chemical and biological effect. A latent period exists between the physical exposure and the development of the first symptom during which time the above noted multiplication phenomenon occurs. A marked variability occurs in the susceptibility of certain cells and tissues to ionizing radiation, ranging from the almost immediate reaction of the extremely radiosensitive lymphocytes, grading through the less sensitive bone marrow gonads intestinal epithelium and skin to the remarkably resistant nerve and muscular tissue Exposure of an individual to a given dosage of ionizing radiation is accompanied by a fixed type of pathology However, the examination of this material will not indicate survival or death of the individual—a phenomenon common to numerous disease states Many of the effects encountered, as in other disease states, appear to be irreversible with a return to a more normal physiologic pattern However the residuals of such damage definitely persist, and lead toward development of premature aging carcinogenesis potential genetic effects decreased fertility and induction of cataracts. Finally the many effects observed are not duplicated by a single agent or disease process.

It is quite obvious that radiation exposure leads to certain changes in cells and tissue which combine into that physiological pattern known as the radiation syndrome The cellular changes of physiologic nature which occur following radiation exposure include alterations in permeability changes in certain enzyme systems depression and alteration of protoplasmic streaming changes in respiration and the like Greater difference occurs in the type and extent of the reaction in the various tissues of an animal—the phenomenon of varying radiosensitivity Tissues of the hematopoietic system are the most sensitive of body tissues. The lymphocyte erythroblast and granulocyte in that order are sensitive to sublethal amounts of radiation. The germinal tissues of the testes and the developing follicles of the ovary show only slightly lesser sensitivity Cells of the intestinal mucosa and the germinal layer of the skin are next in order fol

lowed in turn by parenchymal cells of the liver kidney pancreas and adrenal muscle, fibrous tissue, and nerve are quite resistant. Since the most sensitive tissues react almost immediately following exposure, it is not surprising to note that depressions in lymphocyte and granulocyte levels of the peripheral blood occur during the so-called latent period when no clinical effect is apparent.

It is also important to mention at this time that the clinical pattern of the radiation syndrome can be altered by a great number of modifying factors These include the nutritional state of the individual, certain factors related to the external environment, including temperature and humidity presence of intercurrent infection, age, activity and the like. The marked influence of these modifying factors makes it almost impossible to gauge the extent of the injury and its ultimate prognosis.

Physiologic Alterations. Following whole body exposure to ionizing radiation a series of physiologic events occurs in moderate to rapid order The rapidity of the onset and severity of the state depend primarily on the total amount of radiation received An individual so exposed, passes through the now well known signs and symptoms of the radiation syndrome which are fairly constant from species to species These include the nausea and vomiting, the latent period without symptoms, loss of hair due to sensitivity of the epithelial cells the early metabolic changes the anorexia, general malaise, fever possibly related to cellular breakdown and infection, the signs of hemorrhage into all tissues as related to marked depression of coagulation mechanisms, plus the rapid emaciation, followed shortly by death. A large number of physiologic observations concerning the physiological effect of lethal exposures to ionizing radiation have been made While most of these have been obtained from animal experimentation it is important to state that the observations made upon the Japanese tend in general to follow those trends observed in the animal studies These can be briefly discussed as follows.

An initial loss of weight usually occurs during the first two to three days associated with prostration, nausea and vomiting, diarrhea, and reduction of water intake Following this initial state a tendency toward stabilization follows during the latent period. With the reappearance of toxic symptoms fever and infection, a secondary weight loss occurs The weight loss is similar to that of starvation and is approximately of the same magnitude In regard to protein constituents, most studies indicate that the observed changes can be accounted for by the starvation, although a possibility of a small added nitrogen loss due to tissue breakdown exists No change in total circulating protein is noted. In some instances a reduction in albumin and rise in globulin is observed during the terminal phase. In high exposures a depression of gamma globulin has been noted. Changes in NPN and urea nitrogen are not seen until the terminal phase Creatinine values are within normal limits. Alterations in kidney clearance occur only with definite lesions (usually hemorrhage) in that organ Certain alterations in nucleic acid metabolism have been observed. Delay in absorption of glucose is evident during the first twenty four hours following which a return to normal is seen Many bizarre changes in glucose tolerance curves have been recorded during later phases The lactic acid values and blood pyruvic acid

values are slightly reduced A rise in blood lipids and definite lipemia may be noted Acetone bodies usually occur with dehydration and only in certain species Lipid content of the various tissues may be decreased particularly in the adrenal cortex, which at the same time shows a reduction in vitamin A concentration Animals surviving a fourteen to twenty-day period usually demonstrate a complete absence of fat at autopsy indicating increased mobilization and usage Alterations in fluid and electrolyte balance vary from species to species and are more prominent with high exposures Distention of the intestinal canal with fluid and electrolyte loss occurs in rats during the first six hours This state is later compensated for by an increased water intake In dogs this change is not striking In man certain alterations of lesser extent are noted There is no altered absorption of fluids from the gastrointestinal canal so far as is known After the initial period a rise in serum chloride and a decrease in gastric acidity may be found. Gradual increase in plasma volume offsets the decrease in circulating red cell mass with the blood volume remaining relatively constant The interstitial space measured by thiocyanate shows no marked alteration

Immunologic phenomena show definite change Antibody production is reduced or inhibited if the radiation precedes the onset of the antibody formation. However if the stimulus has been initiated prior to the exposure no depression occurs. In smaller dosage levels an apparent stimulation of antibody production is initiated by the radiation

Much discussion has been raised concerning the effect of ionizing radiation on the adrenal and its responses It is certain that many of the reactions to lethal dosage are suggestive of adrenal stimulation Increased adrenalin levels have been observed and it has been suggested that hyperglycemia may be associated with this reaction As is common, the physiologic response in many respects resembles the adaptation syndrome or alarm reaction of Selye Shielding of the adrenal has proven to be beneficial in certain instances. Beneficial effects following the administration of cortical extracts, cortisone desoxycorticosterone and ACTH have not been observed In most instances a pronounced unfavorable reaction is produced. An increase in 17-hydroxycorticosteroids has been observed in the dog during the first twenty four hour period following lethal exposure

Radiation Syndrome As with the classification of certain clinical disease states the radiation syndrome may be divided into specific phases These are listed in Table 2 and will be referred to in the general discussion

TABLE 2

SYMPTOMS AND SIGNS OF RADIATION SYNDROMES

1 Shock reaction—one to two hours after exposure
2. Latent period (no definite symptoms)—four to fourteen days.
3 Infection and toxicity—nine to thirty days.
4 Hemorrhage—fourteen to thirty days.
5 Anemia and malnutrition—twenty four to sixty days.
6. Convalescence.

With very severe exposure these various phases tend to be markedly shortened The latent period may be replaced by a condition of general malaise without specific symptoms The periods of infection toxicity and hemorrhage tend to overlap to the extent that all appear

at the same time. With extremely high exposure a toxic death may occur in which no specific symptoms of infection, hemorrhage, and the like are found. With low exposure, many or all may be minimal or absent unless the added physiologic burden of complicating injury is added.

The three major clinical entities which have been described in the human may be classified as (1) very severe (2) severe (3) mild to moderately severe in their reaction to acute whole body ionizing radiation These will be discussed in order

In very severe radiation injury caused by radiation dosages of 600 r or more to the whole body the initial or shock reaction occurs almost immediately after the exposure and is accompanied by intractible vomiting which may persist for only several hours but in certain severe cases has been known to persist for several days or more These individuals show a mild fall in blood pressure accompanied by the pallor as seen in primary or neurogenic shock. The latent period is absent or shortened, and although no definite symptoms may be present, a general malaise and prostration are evident. The symptom of diarrhea appears within several days and is followed immediately by a rapidly rising fever of fulminating type Death occurs usually within the fifth to ninth day Some hemorrhage and epilation may develop terminally Early evidence of infection may appear in cases surviving as long as nine days It is felt, however that the cause of death is related to severe tissue destruction rather than to the infection or hemorrhages which appear as terminal entities.

The most significant laboratory finding in the very severe exposure is an early profound, progressive depression in the leukocyte count, appearing almost immediately and extending to very low levels by the end of the first week. Mortality of this group approaches 100 per cent (exposure of 400-600 r)

In the moderately severe case, shock reaction with nausea and vomiting usually appears within one to two hours after exposure and rarely persists longer than twenty-four hours. This reaction is followed by a significant latent period in which no definite symptoms are found. A general malaise or asthenia may be present but is not characteristic of all cases. At some time between the eighth and twentieth day the individual may become ill with the development of a progressive nonspecific toxicity and fever This is followed by the period of infection, associated with profound depression of the circulating leukocytes Clinically in view of its marked involvement of the pharyngeal and pulmonary systems, the infection resembles the clinical entity of agranulocytic angina following aplastic anemia Shortly after infection appears and in certain instances almost simultaneous with it, a period of widespread hemorrhage occurs in which loss of blood is evident into the skin, gastrointestinal canal, lungs, serous surfaces, and other organs. Diarrhea during this period is invariably bloody Hematemesis and epistaxis are common. Bizarre cardiac arrhythmias are found associated with epicardial endocardial, and myocardial hemorrhage Electrocardiographic changes occur Epilation largely confined to the scalp may develop at any time after the fourteenth day and may be the first clinical sign During this period of acute illness with fever infection hemorrhage, and general weight loss associated with various metabolic and water balance disturb-

values are slightly reduced. A rise in blood lipids and definite lipemia may be noted Acetone bodies usually occur with dehydration and only in certain species Lipid content of the various tissues may be decreased, particularly in the adrenal cortex, which at the same time shows a reduction in vitamin A concentration. Animals surviving a fourteen to twenty-day period usually demonstrate a complete absence of fat at autopsy indicating increased mobilization and usage Alterations in fluid and electrolyte balance vary from species to species and are more prominent with high exposures Distention of the intestinal canal with fluid and electrolyte loss occurs in rats during the first six hours This state is later compensated for by an increased water intake In dogs this change is not striking In man certain alterations of lesser extent are noted There is no altered absorption of fluids from the gastrointestinal canal so far as is known After the initial period, a rise in serum chloride and a decrease in gastric acidity may be found Gradual increase in plasma volume offsets the decrease in circulating red cell mass with the blood volume remaining relatively constant The interstitial space measured by thiocyanate shows no marked alteration.

Immunologic phenomena show definite change. Antibody production is reduced or inhibited if the radiation precedes the onset of the antibody formation. However if the stimulus has been initiated prior to the exposure, no depression occurs In smaller dosage levels an apparent stimulation of antibody production is initiated by the radiation.

Much discussion has been raised concerning the effect of ionizing radiation on the adrenal and its responses It is certain that many of the reactions to lethal dosage are suggestive of adrenal stimulation. Increased adrenalin levels have been observed and it has been suggested that hyperglycemia may be associated with this reaction. As is common the physiologic response in many respects resembles the adaptation syndrome or alarm reaction of Selye Shielding of the adrenal has proven to be beneficial in certain instances Beneficial effects following the administration of cortical extracts, cortisone desoxycorticosterone, and ACTH have not been observed. In most instances a pronounced unfavorable reaction is produced An increase in 17-hydroxycorticosteroids has been observed in the dog during the first twenty four hour period following lethal exposure

Radiation Syndrome: As with the classification of certain clinical disease states, the radiation syndrome may be divided into specific phases These are listed in Table 2 and will be referred to in the general discussion

TABLE 2

SYMPTOMS AND SIGNS OF RADIATION SYNDROMES

1. Shock reaction—one to two hours after exposure
2. Latent period (no definite symptoms)—four to fourteen days.
3. Infection and toxicity—nine to thirty days.
4. Hemorrhage—fourteen to thirty days.
5. Anemia and malnutrition—twenty four to sixty days.
6. Convalescence.

With very severe exposure these various phases tend to be markedly shortened. The latent period may be replaced by a condition of general malaise without specific symptoms. The periods of infection toxicity and hemorrhage tend to overlap to the extent that all appear

at the same time. With extremely high exposure a toxic death may occur in which no specific symptoms of infection hemorrhage, and the like are found. With low exposure many or all may be minimal or absent unless the added physiologic burden of complicating injury is added.

The three major clinical entities which have been described in the human may be classified as (1) very severe (2) severe· (3) mild to moderately severe in their reaction to acute whole body ionizing radiation These will be discussed in order

In very severe radiation injury caused by radiation dosages of 600 r or more to the whole body the initial or shock reaction occurs almost immediately after the exposure and is accompanied by intractible vomiting which may persist for only several hours but in certain severe cases has been known to persist for several days or more These individuals show a mild fall in blood pressure accompanied by the pallor as seen in primary or neurogenic shock The latent period is absent or shortened, and although no definite symptoms may be present, a general malaise and prostration are evident. The symptom of diarrhea appears within several days and is followed immediately by a rapidly rising fever of fulminating type Death occurs usually within the fifth to ninth day Some hemorrhage and epilation may develop terminally Early evidence of infection may appear in cases surviving as long as nine days It is felt, however that the cause of death is related to severe tissue destruction rather than to the infection or hemorrhages which appear as terminal entities

The most significant laboratory finding in the very severe exposure is an early profound, progressive depression in the leukocyte count appearing almost immediately and extending to very low levels by the end of the first week Mortality of this group approaches 100 per cent (exposure of 400-600 r)

In the moderately severe case shock reaction with nausea and vomiting usually appears within one to two hours after exposure and rarely persists longer than twenty-four hours. This reaction is followed by a significant latent period in which no definite symptoms are found A general malaise or asthenia may be present but is not characteristic of all cases At some time between the eighth and twentieth day the individual may become ill with the development of a progressive nonspecific toxicity and fever This is followed by the period of infection, associated with profound depression of the circulating leukocytes Clinically in view of its marked involvement of the pharyngeal and pulmonary systems the infection resembles the clinical entity of agranulocytic angina following aplastic anemia. Shortly after infection appears and in certain instances almost simultaneous with it, a period of widespread hemorrhage occurs in which loss of blood is evident into the skin, gastrointestinal canal lungs, serous surfaces, and other organs Diarrhea during this period is invariably bloody Hematemesis and epistaxis are common. Bizarre cardiac arrhythmias are found associated with epicardial, endocardial, and myocardial hemorrhage Electrocardiographic changes occur Epilation largely confined to the scalp may develop at any time after the fourteenth day and may be the first clinical sign During this period of acute illness with fever infection, hemorrhage, and general weight loss, associated with various metabolic and water balance disturb-

ances also occurs. In addition to the profound leukopenia a definite fall in circulating red blood cell mass is noted Terminally these individuals show a rapidly rising fever severe emaciation, and die in coma and delirium between the twentieth and fortieth days Mortality in this group is estimated at approximately fifty per cent.

In individuals with complicating injuries from trauma and burns, the appearance of the radiation syndrome is marked by a rather widespread infection and disruption of previously healing wounds A general sepsis may occur shortly before death.

Since in mild to moderately severe cases no symptoms are shown in the first twenty four hours the likelihood of exposure can only be judged from the location of the individual within the target area No definite symptoms occur in the first two to three weeks after the exposure At the end of this time a definite loss of appetite and general malaise may appear Some soreness of the throat may be present without hemorrhage but accompanied by a definite thirst. Pallor of the skin is common on the skin and mucous membranes may be found petechiae Diarrhea occurs but is not bloody in character Definite weight loss is associated with the anorexia Epilation may appear at any time after the fourteenth day and is usually confined to the scalp The blood counts of these individuals show a moderate depression of the leukocyte count. Lymphopenia is observed during the first two weeks following an exposure Complicating injury related to burns and trauma may increase the severity of the reaction producing symptoms typical of the severe case at a later time Recovery of all individuals is likely unless complications due to previous poor health or superimposed injuries or infections occur

A summary of the clinical symptoms of radiation sickness is tabulated in Table 3 It is again stressed that the higher the dosage of radiation received the more acute is the onset of symptoms In turn the latent period becomes shortened to absent and the tendency toward absence of infection or hemorrhage characteristic of the later periods, less evident With lower dosages the initial symptoms disappear the latent period becomes prolonged, infection may be minimal or absent, hemorrhage is minor and the symptoms of weakness, anorexia and general malaise form the major complaints Between these two extremes various grades of severity exist Each must be recognized as soon as possible if beneficial therapy is to be instituted

It is obvious that much information has been sacrificed in order that a brief, general account can be made For more complete information reference should be directed toward the many publications on the various aspects of the radiation syndrome

Laboratory Diagnosis In addition to the estimates concerning severity of the radiation syndrome which can be made from the analysis of signs and symptoms, some indication as to the severity of the exposure can be observed in changes of the peripheral blood After *very severe* exposure the total white blood cell or leukocyte count decreases to less than ten per cent of its original value within one week. A later reduction to levels of 50 to 100 cells per cu mm may occur shortly before death With *severe* exposures the decrease is of the same order although the time required for maximum depression extends to between the seventh and fourteenth

TABLE 3

CLINICAL SUMMARY OF THE RADIATION SYNDROME

Time After Exposure Days	*Less Severe*	*Severe*	*Mild to Moderately Severe*
	600 r +	400 500 r	100 to 300 r
1 to 6	Primary Shock Nausea and vomiting 2 to 24 hours	Nausea and vomiting after 1 to 2 hours	
	Latent Period No definite symptoms	Latent period No definite symptoms	No definite symptoms
7 to 10	Diarrhea Oropharyngeal inflammation Fever Rapid emaciation Death		
12 to 14		Epilation Anorexia General malaise Toxicity and fever Severe oropharyngeal lesions Pallor Hemorrhage-petechiae, melena, hematemesis, epistaxis	
14 to 21	Approximately 100% mortality	Emaciation Death	Epilation—rare
22 to 60		Approximately 50% mortality	Anorexia General malaise Sore throat Pallor and anemia Moderate emaciation No mortality except in complicating disease

day With mild to moderate exposures a definite reduction is evident but rarely falls to the critical level of less than 1000 cells In the mild group intercurrent infection or complicating injury may result in profound reduction in leukocyte levels with subsequent mortality

Since of the hematopoietic organs the lymph nodes and spleen are the most sensitive, the most marked changes in the peripheral blood counts occur in total lymphocyte counts Even in mild to moderate exposure a definite depression in lymphocyte count is noted within a few hours after exposure with pronounced depression occurring within the twenty four hour period. In the opinion of some observers total lymphocyte

count of less than 800 to 1000 cells per cu mm within the forty-eight hour period after exposure is indicative of very severe radiation injury It is important to note that in cases of questionable exposure the presence of a normal to slightly depressed total lymphocyte count indicates slight injury at most.

Reduction of total leukocyte counts to less than 1000 cells per cu mm is perhaps the best single laboratory index as to the severity of the exposure This is particularly true if the decrease occurs within the first week following exposure

A relatively slow decrease in *platelets* occurs during the first three to four days after exposure Within the next ten days a rapid fall is evident reaching a level of less than 20 000 per cu mm by the end of the second week This coincides with the appearance of coagulation de*fect and hemorrhagic manifestations.* However all hemorrhagic phenomena cannot be attributed to deficiency of platelets alone

Red blood cell formation in the marrow ceases with the radiation exposure If the life span of the erythrocytes of approximately 100 days is not altered by radiation, a decrease in existing red cells of approximately one per cent per day is to be expected from lack of formation alone The decrease however in total red cells is greater than the one per cent per day loss with hematocrit levels dropping to sixty and seventy per cent of control value within the first two weeks. With the onset of hemorrhage this decrease becomes precipitous unless corrected by frequent transfusions Following the hemorrhagic period a definite anemia is present which is slow in response to any type of treatment and may require transfusion for correction It must be noted that the rapidly decreasing hematocrit or red blood cell count, even in absence of hemorrhage indicates a severe radiation injury and is a bad prognostic sign Reticulocytes in the peripheral blood disappear rapidly and remain absent from blood smears for three to four weeks after the exposure Their reappearance in the peripheral blood of a convalescent individual constitutes an excellent prognostic sign

It must be once more emphasized that the close observation on progress and severity of the clinical signs and symptoms forms the best method of evaluation as to the severity of the radiation syndrome Definitely false impressions can be gained by relying too closely upon laboratory information. As is true in clinical medicine it is recommended that laboratory tests be used primarily as a method of following the progress of the disease state In the event of a serious emergency too great an emphasis on the use of extensive laboratory procedures in the follow-up of radiation injury should not be considered For this reason alone, discussion of laboratory measures has been intentionally abbreviated

Analysis of Therapeutic Procedures Possibly of Use in the Radiation Syndrome While it is true that a large number of agents and procedures exist which can alter the course of the radiation syndrome considerably it is necessary to limit direct consideration to those which can be used after the radiation has been received or which by their presence alter or influence the reaction at the time of exposure Of the latter partial body shielding is the only factor of significant importance Direct protection of areas of the body from the ionizing radiation spares the injurious effect administered to all the cells and tissues of that area. Consequently in

jury is limited to the nonshielded regions which as in therapeutic x rays receive considerably higher dosages without lethal effect. After experimental shielding of various portions of the body during radiation exposure animals are able to withstand extremely high dosages without lethal effect It must be commented however that such animals do show residual changes in the unshielded tissues related to the high radiation level administered

Of the procedures or agents which have been effective if used therapeutically after exposure has been received, the following have some importance The transfusion of freshly prepared splenic brei or homogenates into mice within the first twenty four to forty-eight hour period after lethal dosage of radiation has resulted in the immediate survival of individuals at a level twice the 100 per cent lethal dose for the species Some recent evidence indicates however that this protection is not only species specific but also strain specific If these recent observations are correct, the procedure difficult as it is would have little clinical value Also the use of such a technic within forty-eight hours of the injury would be impractical in a large number of casualties.

A similar protection has been gained in guinea pigs by the bone marrow homogenates. This is also true only if the transfusion is given in a twenty four to thirty-six hour period

Several studies have been carried out on replacement of approximately one-fifth of the total blood volume of severely radiated animals by fresh, unradiated blood from a normal typed, cross-matched donor Successful results have been observed in some experiments but procedure may only be of value if carried out within the two to four hour period following exposure As such it becomes extremely impractical and of dubious value as a general emergency measure

Observations made following the Japanese explosions and confirmed on experimental animals indicate that rest is of definite importance in severely radiated individuals Humans and animals receiving sublethal dosage of radiation (by calculation in humans and by direct measurement in animals) developed significant mortality if exercised during the postexposure period For this reason it is recommended that in exposed individuals complete bed rest during the latent period may have remarkable benefit in promoting increased survival

The use of wide spectrum antibiotics, aureomycin and terramycin in particular is beneficial in individuals receiving moderately severe radiation exposure provided that the medication is administered within a twenty-four to forty eight hour period after the radiation is received In certain species of animals (dogs) this results in a definite improvement in morbidity as well as mortality The use of these antibiotics after development of the first signs of radiation illness has not been successful as regards improvement in mortality It is probable that the major improvement resulting from the use of these antibiotics results from the control of infections originating from the gastrointestinal, skin and pulmonary systems. The use of penicillin and streptomycin is encouraged particularly in those individuals with combined injury and also where a susceptible organism is found Chloramphenicol would be used with caution due to the possible injurious effect on a severely injured hematopoietic system

The use of whole blood transfusion

has been recommended as a method of supporting the animal. A large number of experiments have been carried out in animals using this method. Certain general statements can be made concerning the value of whole blood transfusion in the irradiated animal. The use of correctly typed, cross matched whole blood is recommended if definite clinical indication exists for its use. Such indication is definite blood loss either due to hemorrhage or to anemia in the later radiation state. During the earlier period, use of whole blood to combat shock, severe burns, plus other possible indications as direct hemorrhage, is recommended. There is no evidence to contradict the fact that whole blood given during the early period of the radiation syndrome may be detrimental as has been stated by some experimenters. Administration at routine intervals without clinical indication has produced no improvement either in morbidity or mortality of severely injured individuals.

During the last few years other substances of possible value in the treatment of radiation have been suggested. Of these agents most emphasis has been placed upon the value of the antiheparins, protamine and toluidine blue and also the vitamin P substances particularly rutin, in the control of hemorrhage. While these were reported to be beneficial in early experiments recent studies have been unable to show measurable benefit.

Comment must be made also concerning the use of cortisone, ACTH and other adrenal supplements in the irradiated individual. Experimentally the use of these materials in the irradiated animal has invariably been detrimental and accordingly it must be stressed that these materials should not be administered to individuals during the course of the radiation syndrome unless specifically indicated in the control of the disease processes. It is possible that in the future specific information may become available as to the appropriate time and dosage of these substances for use at specific stages in the radiation syndrome.

Treatment of the Radiation Syndrome. At the present time no *specific treatment* is available for use in the radiation syndrome. Proper supporting therapy with emphasis on the control of the complicating factors of infection, hemorrhage, nutritional deficiencies, abnormalities in fluid and electrolyte balance, anemia and other possible individual changes is tremendously important. It is obvious that early recognition of injury plus early institution of supportive procedures *will save many an* individual who might otherwise die.

No procedure at present available will be of value for those individuals who receive a very severe exposure—in dosages of 600 r or more of total body irradiation. One must remember however that these individuals even though evacuated from areas receiving such a *high dosage may have had shielding* sufficient to lower substantially the total *radiation dosage. Hence it is* impossible to make an arbitrary decision on any individual evacuated from a high exposure area without careful analysis of the clinical course which will demonstrate the nature and severity of the injury. Individuals receiving less than 600 r are classified as severe exposures and may be saved if certain principles of treament are carefully observed. In this account emphasis will be placed entirely on the few practical methods available at the present time.

Perhaps the most important single

supportive measure is the removal of the casualty to an area where complete bed rest regimen can be instituted There specific care must be given toward provision of a liquid or bland diet, and prevention of possible infection with emphasis on hygiene of the skin and mucous membranes A good food intake is desirable and during the first one to two weeks a bland, high caloric diet may be preferable Careful surgical attention of complicating wounds and injuries must be carried out. Particular attention should be directed toward control of such lesions during that period in which the marked leukopenia is present (after the seventh day) The use of antibiotics is indicated for the control of infection as well as other possible detoxifying actions which such materials may have If severe radiation injury is certain it is wise to start the antibiotic therapy as soon as possible after the injury (within forty-eight hours) In view of the high incidence of infection with gram negative organisms from the gastrointestinal canal, the choice of a wide spectrum antibiotic such as aureomycin or terramycin is preferable If forms develop resistant to these antibiotics during the syndrome a shift to penicillin and streptomycin may be indicated. Antibiotic therapy for other indications, as in burns and trauma, would depend entirely upon the nature of the infection as determined by bacteriologic examination. Chloramphenicol should be used with caution in view of the observed depressive effect that this antibiotic may have on an already deranged bone marrow

Transfusion of correctly typed and cross-matched whole blood may be a life-saving measure It is certain that blood must be used in the treatment of burns and injury in the individual whether or not whole body radiation has been received No deleterious reactions have appeared from such use in the experimental animal although failure to type and cross-match blood carefully can result in transfusion reactions of bizarre nature, often of serious consequence In a series of 400 or more transfusions carried out in this laboratory no hemolytic or other type of transfusion reaction has been observed If transfusion is to be given to an individual with preexisting hemorrhage in order that the hemorrhagic state not be extended, caution must be observed. It is not desirable to maintain hematocrits in excess of eighty per cent of the normal values After disappearance of the hemorrhagic tendency in the convalescent individual it may become necessary to combat the refractory anemia by administration of correctly typed cross-matched whole blood.

Attention must be given at all times to the maintenance of normal water and electrolyte balances which may vary to a considerable extent during the course of the disease During the convalescent period it is quite important to prevent development of epidemics of intercurrent infection in these individuals.

In summary of the proper treatment of individuals suffering from the radiation syndrome the following outlined procedure is presented.

1 *Shock reaction (one to two days)*
   (a) Complete bed rest with sedation if necessary
   (b) Adequate amounts of oral fluid and preferably a liquid high caloric diet.
   (c) Antibiotic therapy should be instituted at this time if not already in use due to com-

plicating injury Clinical dosages of aureomycin and terramycin to be 2 to 3 Gm daily of penicillin 300 000 to 1 000 000 units daily

2 *Latent period* Continue rest and sedation. Evacuation to rest areas during this time If chloride loss related to vomiting etc. has developed supplemental sodium chloride should be given either by mouth or parenterally A bland diet preferably high caloric should be given to prevent further injury to the already seriously deranged gastrointestinal canal This bland diet should contain a definite amount of protein (six to ten per cent) as recent evidence suggests that nutritional requirements demand this if survival is to be maximal During this period, transfusion should be carried out for indications other than those directly associated with radiation Attention should be given toward promotion of good oral and skin hygiene Make every attempt to control injuries received at the time of exposure, avoiding rigorous therapeutic methods such as unnecessary or complicated surgical procedures

3 During the *phases of toxicity infection and hemorrhage* complete bed rest is still essential It may be desirable during this period to shift the antibiotic from aureomycin or terramycin to a penicillin and streptomycin maintenance dosage Transfusion with compatible typed and cross matched blood will be necessary if rapid hemorrhage develops and the hematocrit falls to critical levels The bland diet of high caloric nature with adequate protein is continued Careful observation for local infection should be made and culture for the presence of antibiotic resistant bacteria carried out if technically possible Blood cultures may be taken to determine if the rapidly rising fever is septic in origin All intravenous administration of fluids or blood must be carried out with extreme caution in order that hemorrhage is not aggravated

(4) During the period of *anemia malnutrition and convalescence* adequate high protein, high carbohydrate diets should be given. Excessive exercise should be avoided Blood supplements including replacement iron, should be given. Great care must be taken to avoid the severe intercurrent and epidemic infections and high mortality as observed in the Japanese after the atomic explosions.

Extensive experimentation is now in progress for the development of new therapeutic methods It must be emphasized that no specific treatment for radiation injury has been developed. Rest, antibiotics good nursing care, and judicious use of whole blood transfusion constitute the only practical measures and can be life saving Complications due to burns and various types of injury increase the severity of the reaction to radiation Every attempt must be made toward avoiding too extensive or rigorous treatment in the handling of the radiated casualty Following recovery from various phases of the radiation syndrome a corrective therapeutic procedure can be carried out without undue risk.

In the preceding account every attempt has been made toward the elimination of all but the most essential facts necessary for an understanding and appreciation of the radiation syndrome in its complexity For more detailed information, reference should be made to the literature listed on the next page

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EARL B BARNES M D

68

The Art of Bandaging

BANDAGING constitutes the first practical field with which the surgeon must become familiar Wounds including lacerations abrasions, and puncture types require scrupulous handling, and the art of bandaging these wounds is an important part of surgical care Bandaging is only learned by practice and painstaking attention. A surgeon is expected by the patient to display skill and finesse in applying a bandage that will be durable and neat. A neat dressing usually indicates a good job beneath A carelessly applied bandage may cause great discomfort, may permit the introduction of infection, and may imperil one of the patient s extremities

The numerous types of bandages include the common type roller bandage, the adhesive bandage the elastic bandage, and the triangular bandage The roller bandage (Fig 1) can be made from gauze muslin rubber or elastic webbing the width and length of which depends on the part to be bandaged In order to prevent discomfort to the patient, the roller bandage of this type should be free of wrinkles or seams The "Ace" bandage owes its elasticity to the weave of the cloth while the "Elastoplast" bandage owes its elasticity to rubber The elastic bandage should be used only by those completely familiar with bandaging

The *basic materials of bandages are* gauze crinoline muslin rubber and elastic webbing Gauze is most frequently used because it is light porous soft, and readily adjustable Crinoline is used for plaster of paris bandages because it holds the plaster of paris better than gauze. Muslin is strong inexpensive and can be used more than once Rubber and elastic webbing are used for firm support of a part.

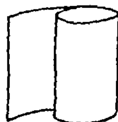
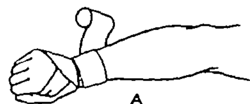


FIG. 1 A roller bandage

Use of Bandages. The functions of bandages are (1) to retain dressings in position (2) to prevent sepsis, (3) to immobilize the injured part, (4) to secure splints, (5) to prevent swelling, (6) to create pressure and thus prevent bleeding, and (7) to increase warmth of the bandaged part.

Rules of Bandaging Certain fundamental rules should be followed in the technic of bandaging Always commence bandaging from within outwards, and either from below upwards or from above downwards The roll should be

held in the right hand with the left hand holding the free end the roll is then passed around the part with the right hand thus keeping even pressure through out the application of the bandage Two or three overlapping turns will secure the bandage and keep it in place. If the bandage is applied too tightly impair



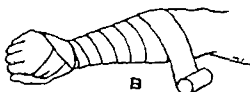
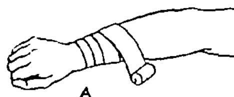


FIG. 2. Spiral bandage



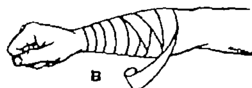


FIG. 3 Spiral reverse.

ment of circulation with subsequent swelling, discoloration numbness and tingling, pallor coldness, and subsequent paralysis or gangrene may ensue. The tips of fingers and toes are left exposed in order that color changes may be observed When bandaging a joint, it is better to have it flexed because this allows a certain amount of movement. If the joint is bandaged in the straight position, flexion of the joint may impair

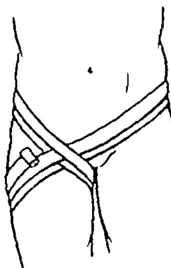
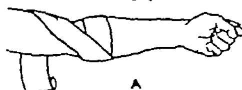


FIG. 4 Figure-of-8 bandage of the hip (ascending spica)



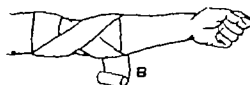


FIG. 5 Figure-of-8 bandage of the elbow Forearm should be flexed ninety degrees.

circulation Bony prominences should be well padded with appropriate materials Use the correct width of bandage for each part to be bandaged. Cover two-thirds of the previous turn and keep the pattern straight. Always try to have gauze between the skin and the bandage. If the leg or arm is bandaged, include the foot or hand to prevent congestion and swelling. Prevent loose bandaging because bleeding may result, the dressing may shift to expose the wound, and immobilization may be lost. Terminate all bandages securely This can be done with adhesive tape, or tying by splitting the end of the bandage for the distance of more than half the diameter of the

part and passing the ends around in opposite directions and tying The use of adhesive tape is the best method for firmly affixing a bandage

FUNDAMENTAL TURNS OF BANDAGES The *circular* bandage is used for cylin drical parts The turns are applied at right angles to the long axis of the part, and each turn overlaps the preceding one.

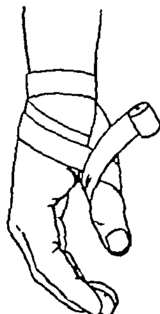


FIG. 6. Spica of the thumb descending.

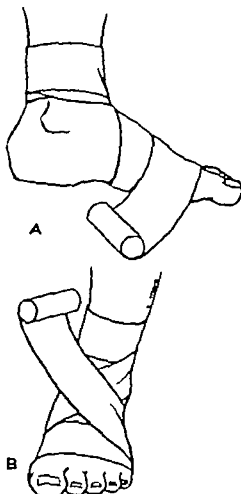


FIG. 8A and B. Figure-of-8 of foot with heel exposed.

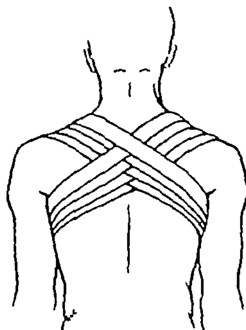


FIG. 7 Figure-of-8 of the shoulders and back.

A *spiral* bandage begins with a circu lar turn that is carried spirally upwards Each turn parallels the preceding one and overlaps it from one-half to two-thirds of its width. The spiral bandage may be ascending or descending· the ascending one is more frequently used (Fig. 2)

A *spiral reverse* bandage is used on conical shaped areas such as the fore-arm, thigh, and leg (Fig 3A) In order to apply a flat bandage and yet permit no gaps, the direction of the spiral turns

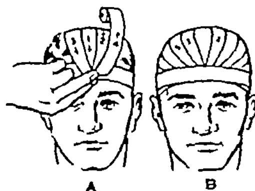


FIG. 9 Recurrent turns for scalp and head. A. Gauze is placed over wound and then the anterior-posterior folds are placed according to illustration. B Bandage is finished with anterior-posterior and latero-lateral placed adhesive tape

must be changed. When a point is reached in applying spiral turns on an increasing conical shape, the reverse may be used (Fig. 3B) the thumb of the left hand is placed at the upper edge of the last turn, the right hand is pronated thus reversing the body of the bandage and the bandage is passed around the limb with the lower edge overlapping one-half of the bandage already applied The spiral reverse is always made towards the operator

The *figure-of-8-turns* are the ones most frequently used in bandaging The figure-of-8 consists of two loops made in the form of an eight (8) and are usually used in covering a joint. It is called a *spica* when a number of turns are applied each a little higher or lower so as to overlap a portion of each preceding turn. The spica is used in the region of the ball and socket joints, *i.e* hip and shoulder (Figs 4 5 6 7 and 8)

Recurrent turns are used to cover the scalp amputation stumps, or extremities First fix the initial extremity by circular turns, then reverse backwards and forwards covering the area, alternat

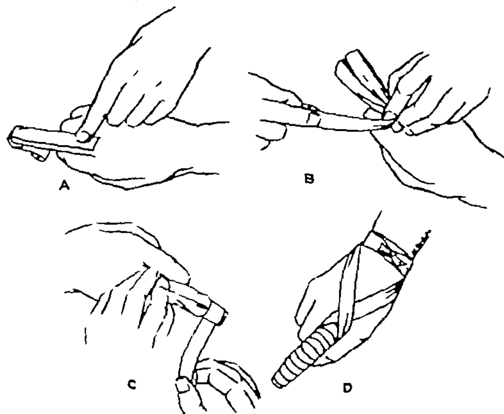


FIG. 10 Recurrent spiral bandage of the finger

ing on each side Complete the bandage with a few firm circular turns over the fixed turns (Figs 9 10 and 11)

REGIONAL BANDAGING In our present machine age, the *fingers* and hands are *frequent recipients* of wounds which need bandaging If the wound is small, a sterile dressing is applied following which a few turns in the circular manner will be adequate However if the wound involves more than a small portion of the finger the *recurrent spiral bandage* (Fig 10) is one which is uniformly used. A sterile dressing is placed on the wound and the bandage is brought forward and backwards (Fig. 10A) around the tip of the finger The base of the recurrent bandage is held in the forefinger and thumb of the bandager (Fig. 10B) Make two more turns lateral to the above and apply a spiral from the tip or as far as necessary up the finger (Fig 10C) Finish off with a figure-of-8 about the wrist and over this bandage apply adhesive tape because the adhesive tape will make the bandage more durable (Fig. 10D)

The *spiral reverse* bandage as has been stated before is aptly applied to conical areas such as the extremities (Fig. 3) The principle of the spiral reverse does not have to be used for the entire length of the extremity but it can

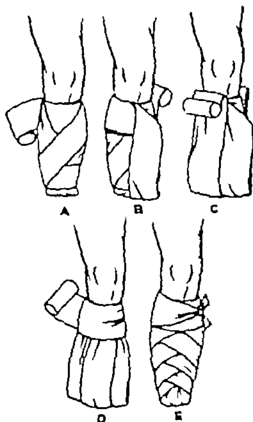


FIG. 11 Recurrent bandage of stump A. Hold dressing in place with loose spiral turns down and up stump B. Start recurrent turn below anterior portion of knee downwards, then under the stump. C Continue bandage back to knee reverse and carry over stump again. Repeat until stump is covered. D Secure turns at base Cover loops with a spiral to the end of the stump. E. Complete bandage with figure-of-8 from end of stump to knee.

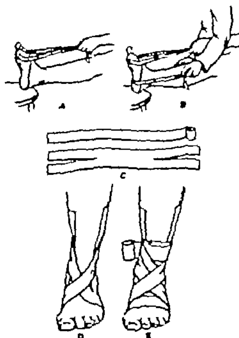


FIG. 12. Figure-of-8 and H" adhesive bandage for a sprained ankle. A. Roller bandage to hold foot in dorsiflexion and eversion. B Roller bandage used to measure length of applied adhesive tape. C. "H" type of adhesive for splinting ankle D H adhesive applied to ankle with the "X" as anterior portion of adhesive splint. E. Figure-of-8 dressing applied over the adhesive tape

be used in those areas where it is felt evident that the bandage will be loose and untidy The different turns can be used to fit the problem at hand

The *ankle* lends itself to the *figure of-8 bandage* to cover wounds and also to immobilize sprains after proper splinting If the ankle is sprained the adhesive should be applied with the foot in dorsiflexion and eversion (Fig 12A) This can be accomplished by placing the patient s heel on a stool. The patient *may hold in his hands the two ends* of roller bandage encircling the ball of the foot from a point at about the head of the fifth metatarsal bone thus pulling the foot upwards and outwards. A separate piece of roller bandage may be used to measure the length of adhesive tape necessary to splint the ankle by measuring from the mid portion of the leg from both sides extending around the heel (Fig 12B) Before applying the adhesive tape paint the medial and lateral portion of the leg with a compound tincture of benzoin A piece of adhesive 7.5 to 10 cm (3 to 4 inches) wide can be torn to make an "H" (Fig. 12C) The center arm of the "H" is placed against the heel, then the posterior portion of the "H" can be used as two longitudinal strips that attach to the medial and lateral sides of the leg, and the anterior portion of the "H" is overlapped as an "X" to stabilize the ankle (Fig. 12D) I have found this to be a very simple application of tape that immobilizes the ankle as adequately as the use of a large number of strips of adhesive. About this adhesive can be applied a figure-of-8 bandage to reinforce the adhesive, thus producing an adequate splinting of the ankle (Fig. 12E)

A *figure-of-8 of the hand* (Fig. 13) can be used for wounds of the hand and wrist. Of course, the figure-of-8 principle can be used for the neck and axillary wounds (Fig 14) thigh and groin wounds, and head and neck wounds, in other words those about movable parts

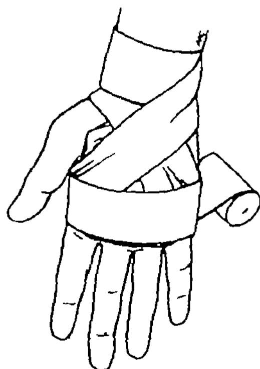


FIG. 13 Figure-of-8 bandage to hand and wrist.



FIG. 14 Figure-of-8 bandage for neck and axilla.

The *crossed bandage of the eye* is applied for wounds of the eye and to protect the eye from light (Fig 15) This

bandage covers one side of the head at a time Care should be taken to provide padding over and behind the ear (Fig 15A) The bandage is applied alternately high on one side of the head, and low on the other (Fig 15B) A piece of gauze can be tied between the eyes about the bandage to cause more compression

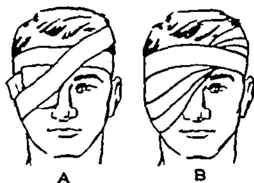


Fig. 15 Crossed bandage of the eye.

The *Velpeau* bandage is good for immobilization of fractures of the clavicle, for immobilization following dislocation of the shoulder and occasionally for temporary fixation of a fractured humerus (Fig. 16) Place fingers of affected side upon opposite shoulder this position pushes the shoulder upward, outward, and backward. There should be pads in the axilla and on the olecranon and sheet wadding should be used

Fig. 16. Velpeau bandage

o separate skin surfaces Continue down across the outer portion of the affected shoulder and upper arm then under and round the waist front (Fig 16A) Continue around the back of the waist, pass ing over the starting end to anchor the bandage Circle the waist over the bent elbow and bring the bandage diagonally up across the back (Fig. 16B) Continue around and downward on to outer por tion of the shoulder then below the elbow each turn ascending and overlapping two-thirds of the preceding turn (Figs 16C and 16D) Terminate the bandage with circular turns over the arm, forearm, and chest (Fig 16D) Adhesive plaster can be used to reinforce the velpeau bandage.

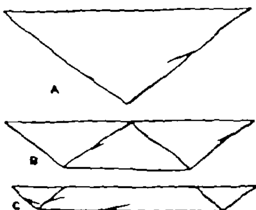


FIG 17 Triangle bandage. A. Bandage made by cutting diagonally across a piece of muslin a meter (yard) square. B Fold apex towards base. C. Fold again towards the base and a cravat bandage is made.

The *triangle* cravat, or handkerchief bandage is very practical and easy to use, but is not commonly employed in hospital work. It can be used for temporary or permanent dressing of wounds, fractures, sprains, dislocations, and for slings (Fig 17) It is made from any

FIG. 18 Sling (triangle bandage) A. With forearm in carrying position, place apex of triangle towards elbow and the base towards the hand. B. Tie the two ends to either side of neck. C. Fold apex of triangle snugly in front of elbow

type of cloth but usually from muslin squares of 1 sq meter (3x3 feet) They can be cut diagonally to form two bandages. The long side of the triangle is called the base the point opposite the base is called the apex The names of the triangular bandages indicate the part of the body to which the bandage is applied.

The *sling* is a form of the triangular bandage which can be used for fractures or injuries of the hand wrist shoulder or forearm It can be applied by placing the apex towards the elbow the base towards the hand with the elbow bent (Fig 18A) Tie the two ends behind the neck on either side (Fig. 18B) the apex of the triangle is pinned snugly in front of the elbow (Fig 18C)

Miscellaneous Bandages The following bandages can be used to fix a dressing to the torso abdomen or the perineum

Montgomery straps are used for dressings that need frequent changing without frequent applications of adhesive tape (Fig. 19) These straps not only aid the patient financially but also decrease the patient s discomfort by avoiding the daily removal of large areas of adhesive tape

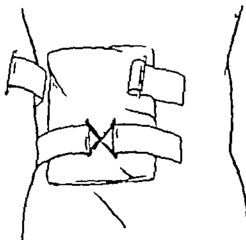
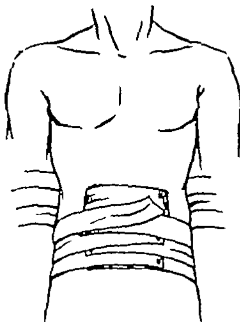


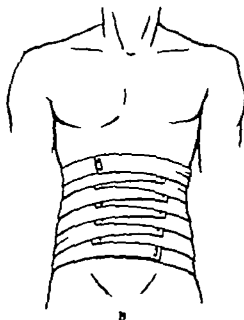
Fig. 19 Montgomery straps

with, at times hair and portions of the superficial skin. Four straps or more of the desired length and width of adhesive



A.

Fig. 20 Scultetus bandage A Lower tails are alternately brought across the abdomen and pinned from below upwards.



B

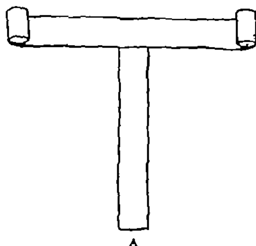
Fig. 20B Complete bandage

tape are folded over an applicator stick covering all but half of the adhesive surface This prevents the strap from sticking to the bandage at the same time allowing the adhesive portion to adhere to the skin. Compound tincture of benzoin may be applied to the skin before application of adhesive tape. Rubber bands are applied to the opposing sticks as illustrated (Fig 19) One may substitute ribbons tied through holes in the straps, but ribbons lack the elasticity of rubber bands

The *scultetus bandage* or the "many tailed" bandage is most frequently used as an abdominal binder to allow early ambulation of the patient following abdominal operations because it is felt that this bandage splints the abdominal musculature thereby helping to prevent wound separation a constant threat when large incisions are made. The bandage may of course be used when frequent dressings are needed This bandage (Fig 20) is usually made from muslin or flannel strips which will reach once and a half around the patient. The middle thirds of these strips are stitched together posteriorly When applying the bandage the lower tails are brought alternately across the abdomen and pinned from below upwards

The *perineal "T" bandage* is an example of the "T" principle (Fig. 21) Muslin strips 7.5 cm. (3 inches) wide are sewn in the shape of a "T" (Fig. 21A) The top of the "T" should encompass the waist The free end of the stem of the "T" is torn for a short distance so that when the stem is brought against the perineum the desired length may be torn to pass the genitals for male patients so that when the top of the "T" is tied about the waist, the perineal strips can be tied to the belt. For the female, the stem of the "T" may be brought in front of the perineum and tied to the waist bandage (Fig. 21B)

MODIFIED T TUBE BILIARY DRAINAGE Ordinary methods of fixing the T-tube following biliary surgery have been unsatisfactory in that unnecessary spilling of the bile on the dressings necessitated frequent changes of dressings. Not only that but unwieldy apparatus has sometimes caused the withdrawal of the T-tube with disastrous results Isabelle DeBella, in 1951 devised a drainage bottle which overcomes these objections The equipment includes a small



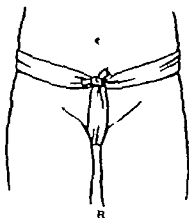


FIG. 21 Perineal "T" bandage.

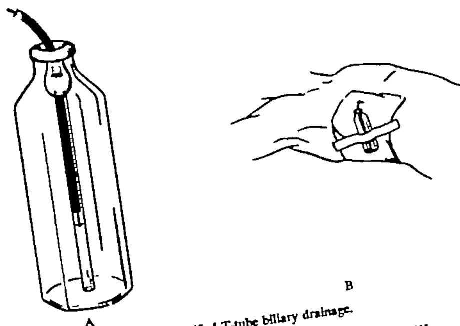


Fig. 22. Modified T-tube biliary drainage.

nursing bottle of 120 to 180 cc. (4 to 6 ounces) capacity a glass tube approximately 10 cm. (4 inches) long and about 0.5 cm. (1/5 inch) in diameter a nipple with a hole enlarged to accommodate the glass tube The nipple is inverted into the bottle (Fig. 22A) and the flange is turned over the mouth of the bottle the glass tube is inserted into the nipple and bottle, and the T-tube is inserted into the glass tubing Adhesive is used to hold the bottle to the dressing (Fig. 22B) This obviates spillage of bile even with inversion of the bottle prevents undue traction on the T-tube and allows more freedom of motion

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Disinfection for Emergency Surgery

Surgical operations can be conveniently grouped as "emergency" and "elective." For a more comprehensive grouping surgical cases may be divided into four groups as suggested by Blalock.[1] His "group one" comprises true emergencies. The other three groups include all electives with the actual time of operation varying, based upon the time required for properly preparing the patient.

In this volume, we are concerned with true emergencies. It is to be remembered, that under conditions of extreme emergencies the use of many of the fundamental principles of surgical procedure, methods of sterilization and disinfection and aseptic technic may have to be modified During times of a great catastrophe as may occur during bombing of and from an atomic explosion in populated areas, this is especially true Many examples can be cited remembering that we are concerned first and foremost with the life of the patient. A patient in severe shock should first be treated for the shock before attempting to treat a wound. The use of a finger dipped into a suitable iodine solution (or even untreated) and then used to stop the bleeding of a punctured wound of certain arteries is justified in order to save a life

Where ideal surgical treatment, including both asepsis and antisepsis is possible, such procedures should be practiced. However it is apparent that ideal conditions cannot be realized always during disaster conditions and especially during violent catastrophes. It is therefore, necessary to be prepared with the best available plan for functioning during such extraordinary emergencies. Though exacting and hard and fast rules cannot be laid down, a definite prearranged overall systematic plan is necessary taking into consideration all possible situations, so that the greatest amount of good to the largest number may result.

Antiseptics Aseptic surgical technic as we know it today must be respected and practiced at all times. It is obvious that antiseptics play a valuable role in this technic.

Exigencies of existing situations may necessitate deviations, changes, or modifications of any prearranged plan. For instance, the water supply may be unsatisfactory or even shut off due to a break in the system, or heating arrangements may not be available, so that proper heat sterilization is not possible Antiseptics then are the only available agents which can possibly be effective for obtaining asepsis of much of the equipment, dressings and other surgical aids

Wounds received during violent and extraordinary catastrophes are usually infected by the time they reach the surgeon The use of an antiseptic cannot and should not take the place of adequate debridement and the usual operative technics However the use of an antiseptic can serve as a helpful aid in conjunction with this treatment.

SELECTION OF AN ANTISEPTIC During emergencies one must think of the availability of an all purpose antibacterial agent. The latter should be suitable for many different services Also it should be preferably a substance or combination of substances in dry form which when mixed with water will make available quickly a suitable antibacterial solution It is possible that the water supply may be affected during such a period and be regarded as contaminated On the other hand the addition of such water to a suitable dry antibacterial agent will not only dilute the latter but also disinfect the water During catastrophes bottles containing liquid antiseptics are apt to be broken and keeping liquids on hand during long storage periods *may result in deterioration,* concentration, or other objectionable changes Valuable space is frequently tided up in stockpiling liquids During atomic warfare consideration must be given to the possibility of irradiation of the chemicals on hand for use later on human beings. Furthermore in atomic explosions it is necessary to be prepared to treat large numbers of injured persons quickly and the demand will be enormous for the amount of supplies required

Disinfectants and antiseptics comprise a large heterogeneous group However certain basic considerations are of importance when selecting an antiseptic and especially one to serve many useful purposes. When used on the human body compounds for use as antiseptics should have the following properties (1) High bactericidal (and if possible also fungicidal) activity (2) low tissue toxicity (3) freedom from specificity *i e* should attack all kinds of microorganisms (4) rapid action (5) penetration, (6) effectiveness in the presence of organic matter especially blood, pus oil grease, and soap (7) safety margin on dilution, (8) effectiveness when exposed to *different temperatures* (especially low) (9) stability (10) ease of application, (11) ready availability (12) low cost, (13) no objectionable odor and (14) color to delineate area treated when used as a skin antiseptic.

There are many antiseptics available on the market. There are the phenolic compounds, the halogens the mercurials the quaternary ammonium salts the dyes and others Many in these groups are proprietary antiseptics Each has its advocates Simultaneous *in vitro* tests corroborated by clinical evidence with proprietary as well as with many nonproprietary antiseptics have revealed that iodine possesses in the highest degree the prerequisites of the ideal antiseptic, especially for the many and varied purposes considered in this chapter

The introduction of new antibacterial agents and the modern methods of promoting them too often obscure the virtues of those which have been used for numerous decades and are still being used effectively The following statement *made fifteen years ago in the editorial* of the New England Journal of Medicine[2] is still true today "Regardless of the solution in which it is used *Iodine is an effective germicide* " It is with this in mind and considering the versatility of this agent, that iodine alone is pre

sented here for the reasons mentioned previously and for others to be given as the antiseptic of choice

Emphasis again must be placed upon the fact that during times of emergencies, we must not accept low standards as a necessary situation or as an existing evil Let us always remember that custom (frequently bad) slovenly habits doubts and especially inertia of members of a prevention team too often account for failures in controlling infection When emergencies arise then and especially then, it is important for workers to think imaginatively Those in positions of responsibility should display a most exacting conscience and knowledge inasmuch as success depends in great measure upon them

PROPERTIES OF IODINE Iodine, a solid crystalline element, bluish-black in color with a bright metallic luster possesses the highest atomic weight of the common halogens It is the only halogen which is solid at ordinary room temperatures (20 C.) and which can change spontaneously into the vapor state without first passing through a liquid phase. The vapor state is referred to as nascent iodine True liquid iodine is rarely seen, except under special laboratory conditions Iodine is only slightly soluble in water (1 3450 at 20 C.) but freely soluble in aqueous solutions containing soluble iodides, and also in many organic solvents

ACTION OF IODINE AS A BACTERICIDE Iodine is a highly reactive element and precisely because it is so reactive, it is a good germicide When iodine acts as a disinfectant, free iodine is the effective agent.[3,4] Sollmann[5] states "Elementary iodine precipitates proteins the iodine being partly absorbed, partly loosely bound and partly converted into iodide ions Since the iodine is loosely bound it continues to penetrate so that the action extends deeply" McCulloch[6] believed that iodine destroyed micro-organisms by the "formation of salts with proteins by direct halogenation"

THE BACTERICIDAL EFFICIENCY OF IODINE In gathering laboratory data on the efficacy of an antiseptic one must recognize that even today there is not available a universal single laboratory test applicable under all conditions In all instances laboratory data should be obtained and interpreted under conditions paralleling as closely as possible those found in actual practice In the final analysis, efficacy under conditions of use (as recommended in labeling) is the important criterion. When an antispetic shows *constantly* satisfactory effectiveness by many different *in vitro* and *in vivo* methods one can then state that it deserves a high rating of usefulness as a bactericidal agent.

Iodine has been used as a bactericidal agent for nearly a century and there are many reports by different workers, including the author as to its antisepticity These reports have shown the high bactericidal efficiency and the low tissue toxicity of iodine One of the most striking characteristics of iodine, especially noticeable to one who has studied the germicidal efficiencies of the medicinal dyes and the complex mercurials is that the concentration of iodine necessary to disinfect does not vary greatly with different species of micro-organisms All of the technics reported have been checked in the author's laboratory All observations indicate that the bactericidal efficiency of iodine solutions depends upon the concentration of free iodine, and that an increase in the amount of free iodine in a solution is indicated by an increase in the bactericidal efficiency

Two Per Cent Iodine Solutions The iodine preparations of choice for use as antiseptics are the two per cent (w/v) iodine tincture (U.S.P.XIV) and iodine solution (N.F IX) [7] For more than two decades, the author has recommended the aqueous iodine solution in preference to the tincture for reasons stated later and given in more detail in articles published by him

It is desirable to clarify the iodine tincture issue since confusion still prevails

Today and since 1947 on the market in this country iodine tincture refers to one preparation and one only the U.S.P tincture containing two per cent iodine 2 4 per cent sodium iodide in diluted alcohol (the final alcohol content is forty-seven (forty four to fifty) per cent) Unfortunately prior to 1947 the same name tincture of iodine referred to a U.S.P preparation (now official in the N F as strong iodine tincture) which differs in composition from the preparation now known as iodine tincture The former contained seven per cent iodine and five per cent potassium iodide in an alcoholic solution (final alcohol content from eighty three to eighty-eight per cent) The tincture of iodine official during earlier years contained an even higher alcohol content. The alcoholic preparation containing seven per cent free iodine is excessively strong and may be irritating when used on the skin and covered tightly Thus strong tincture is not generally recommended for use as an antiseptic but is primarily employed as a counterirritant Unfortunately even today the two per cent iodine tincture containing 2 4 per cent sodium iodide in diluted alcohol is not always used as the antiseptic alcoholic solution but one containing either a stronger iodine or alcohol (or both) content also the iodine-iodide ratio may be different The latter are frequently also labeled iodine tincture Furthermore iodine tincture reported in the American literature prior to 1947 and found at anytime in foreign literature under this name usually refers to a preparation which may be different in composition from iodine tincture U.S.P XIV The iodine tincture situation even in its manufacture has had its short comings as reported in an editorial by Tice [8] Recently the iodide iodine solubility relation in water was established for a limited range at different temperatures This may result in a slight modification for the iodine formulas as to the iodide content.[9]

To avoid the possibility of the use of iodine tincture formulas other than the correct U.S.P formula, a water solution of the iodine iodide (Iodine Solution N.F) is preferred Such a solution avoids the possibility of most of the objections to alcoholic solutions Water is available everywhere even during great catastrophes. Even if the water contained water-borne bacteria it could be used in emergencies if no other supply was available as the water used as a solvent and diluent would be quickly disinfected. Especially for stock piling the proper proportion of powder could be kept mixed or the iodine and iodide be kept separately later to be mixed and dissolved in the water The powders will not be affected by irradiation during atomic warfare and being stable they can be used at a later date for any purpose desired.

Other than the above reasons the water solution of iodine is ideal as an antiseptic for a variety of uses It is of interest to note that mention is made of the use of iodine solutions in water as a wound antiseptic in an editorial in the

New England Journal of Medicine[2] more than fifteen years ago and the statement made then applies just as well today "Facts such as these have appeared in medical literature for years but the majority of us do nothing about it." More than twenty years ago after extensive work in the author's laboratory we reported[10] that a water solution of iodine "containing soluble iodides is more satisfactory as an antiseptic than most of all the other commonly employed marketable antiseptic preparations" In a report on antiseptics for hospital use,[11] the statement is made "In dilute aqueous solutions iodine remains one of the most effective chemical germicides available." Homans[12] states "Watery solutions of iodine are superior germicides." He refers to weak dilutions "not only able to check the growth of bacteria but to kill them, and that in the presence of blood serum." Furthermore, "Its usefulness as a rinsing solution (in the operating room) and as an antiseptic irrigation fluid for both potentially and grossly infected wounds has probably been overlooked." A large number of additional references could be cited. A recent report by Ficarra[13] mentioned later refers to the use of both the N F Iodine Solution and iodine-propylene glycol solutions As noted by the authors [14] if an aqueous solution must be shipped during the cold weather "Propylene glycol can be employed to lower the freezing point of aqueous solutions of iodine Propylene glycol-iodine solutions possess an adhesiveness on human skin, which may be desirable"

Disinfection of the Skin It is an accepted fact today that the skin is never free of bacteria and possibly fungi. The latter include the transient organisms those coming in contact with the skin and the resident organisms, those regarded as the normal inhabitants of the skin The transient bacteria and also fungi consist of a variety of different kinds of micro-organisms Found on the superficial skin surface, their numbers depend upon the cleanliness of the individual and his habits, as he comes in contact with different sources of contamination The pathogenic and more virulent types of micro-organisms are apt to be found among the transient group The resident flora are located in the deeper parts of the skin and especially in the hair follicles and the sebaceous glands The organisms here are probably fairly constant in numbers and have acquired the ability to thrive and grow in an *environment usually* unfit for other types of bacteria to live and multiply

During an operation or after puncturing the untreated skin with a missile or even a needle not only transient organisms but also resident micro-organisms may gain entrance. Generally the resident flora do not cause serious wound infections, unless large numbers are carried along or the wound is such as to make available an environment where conditions are more favorable for their development and growth. Furthermore, we do not necessarily depend upon modern methods of preoperative preparation for the removal of all resident micro-organisms During the operation, by careful attention to operative technic, the latter can be reduced to a minimum and the possibility of their causing infection can be greatly lessened.

On the other hand, the transient bacteria, responsible as they are for most skin infections, can be removed by mechanical and chemical cleansing of the skin.

Preoperative Preparation of the Skin Many transient organisms can be

removed along with dirt and grease by an effective routine vigorous and thorough brushing or scrubbing with every surface of the skin carefully reached This applies both to the operative site especially to smooth areas of the skin as well as to the hands and arms of the operating team Proper mechanical treatment removes fat, oil debris other foreign matter and most of the transient and a high percentage of the resident flora But we cannot rely upon mechanical cleansing alone Furthermore, in the treatment of the skin on certain areas as the scrotum and over superficial growths of the skin vigorous mechanical scrubbing is not possible and an atraumatic technic must be employed As indicated by Walter [15] "Chemical disinfectants must be relied upon to destroy more of the organisms remaining on the clean dry fat-free skin" Pulaski[16] states "Soaps should not be relied upon to produce skin sterility After mechanical cleansing it is necessary to eliminate the transient and resident bacteria Iodine has a wide reputation as an efficient germicide Although the tincture has been so widely used the aqueous solutions of iodine are gaining in prominence as more and more reports appear on their highly germicidal action

For preoperative skin preparation the aqueous solutions possess certain advantages" Lovell[17] advises "Chemical cleansing should be performed to further reduce the number of bacteria on the surface Numerous good antiseptics are available but 3.5 per cent iodine is probably used more frequently than any other chemical on the patient's skin preparatory to the operation." Many other references can be cited but the above will suffice

Disinfection of Skin Before Operation Sufficient evidence has been presented indicating the need for the use of a skin antiseptic following the mechanical cleansing and preceding the surgical procedures The reasons for recommending the use of iodine for this and other purposes are also detailed. A few references indicating the value of iodine for the disinfection of the operative site have been given. A large number of others can be cited including that by Dannreuther[18] who in 1908 discussed the surgical value of iodine He at that time indicated the following "I do not believe that the value of iodine in surgery is as generally appreciated as it deserves," a statement which can be repeated even today If these are not convincing, the following may supply additional proof

Noehren[19] describing his many years of experience with thyroidectomy states "The operative area is wiped with ether to remove all fat and sebaceous material from the skin and this is followed by a not too wet application of half strength tincture of iodine We have never seen any reason for changing to any other antiseptic." Harrison and Cruickshank[20] report on an investigation of "a troublesome incidence of wound infections following thoracoplasty" and various methods of preoperative preparation of the skin They concluded that a one per cent iodine in seventy per cent alcohol was the most suitable skin disinfectant and used this solution as follows "On the operating table the wound area was swabbed three times with iodine solution all preoperative ward preparation was discontinued unless skin pustules were present."

Lipscomb [1] in discussing head injuries and standard methods of treatment of traumatic craniocerebral lesions uses half strength tincture of iodine on the scalp and when necessary packs off the

ostium which connects the frontal sinus with the nasal cavity with gauze saturated in tincture of iodine

Blakemore[22] in a consideration of portacaval anastomosis discusses the routine established at the Presbyterian Hospital in New York City for the treatment of aneurysms Included is "skin preparation by a soap and water scrub followed by alcohol ether iodine and alcohol"

Babcock and Bacon-[3] in discussing the surgical treatment of carcinoma of the large bowel state "We have attempted to sterilize intestinal contents and mucous surfaces about rectal carcinoma locally before operation by irrigation and packing with gauze wet with germicides" Of the different antiseptics tried they indicate they "prefer a 3.5 per cent tincture of iodine" They also employed "careful packing of the rectum with 3.5 per cent tincture of iodine gauze."

Horsley and Michaux[24] in a report of surgery of the colon in an overseas general hospital prepared the skin of the abdomen by treatment with an iodine-alcohol solution.

Venboer[25] discusses operations in cases showing third degree uterine prolapse and in their technic they swab the vagina with a two per cent iodine solution followed by seventy per cent alcohol.

Roman-[6] reports on the classic cesarean section and mentions that in his operative technic he employs "3.5 per cent iodine and alcohol."

Chase-[7] discusses the treatment of cataract and the cataract operation In the latter he states that "Iodine 3½ per cent, is painted on the skin of the lids and cheek and wiped off with seventy per cent alcohol." Atterbury[28] in presenting operating room technic for oral surgical treatment uses in the mouth on the mucous membrane "tincture of iodine and aconite"

Picchioni[29] in a review on skin disinfection states "Of the various germicidal agents included in this review it is concluded that a solution of iodine is a most satisfactory preparation for preoperative skin preparation. Experimentally it was shown that a solution of iodine is bactericidal that it is bactericidal in concentrations which are not toxic to the tissues that it maintains its potency in the presence of foreign proteins, and that its activity is of long duration. It was clinically demonstrated to be nonirritating and in dilutions as low as one per cent shown to be effective in preventing infection." Squire[30] discusses skin disinfection and quotes the work on alcohol by Gardner who "has shown the added speed of action which is attained if one per cent iodine is present, with the practical advantages of demarcation of the area tested."

In comments on disinfection of the skin,[31] Gardner's findings are reported on "a wide range of antiseptics measuring the ability of a single application to achieve virtual disinfection of a standard area of skin on which a suspension of *Staph albus* (or certain other organisms, including *Pseudomonas pyocyanea*) had been swabbed and allowed to dry The only solution that did this regularly in fifteen to twenty seconds was two per cent iodine in seventy per cent alcohol." The statement is made that "iodine in alcohol is thus very suitable for needle puncture or as a single application before operation"

Finally these statements by Walter[1-] are of interest "One of the most striking characteristics of iodine as a germicide is its uniformity of action on different species of micro-organisms.

Aqueous solutions are more effective germicides, do not irritate the tissues, and are painless "

Technic In preparing the field of operation a generous area is included surrounding the proposed incision the area is determined separately for each operation. When the skin antiseptic is to be employed just before the drapes are applied, use one of the iodine preparations containing two per cent free iodine The water solution or water propylene glycol solution is preferred If an alcoholic preparation is desired, iodine tincture containing two per cent free iodine and 2 4 per cent sodium iodide in diluted alcohol is suggested. Rub or swab vigorously the iodine solution into the skin preferably for two minutes (not less than one minute) If rubbing is not advisable or practical the iodine solution should be kept moist on the operative site preferably for five minutes or used for this period of time as a wet dressing If desired, the excess moisture can be wiped with seventy per cent alcohol or a sterile solution of sodium thiosulfate Where there is no objection to the iodine layer it need not be removed but employed as suggested by Ficarra [12] "In accordance with tradition soap and water were employed to cleanse the skin, and this was followed by application of the chemical antiseptic After the iodine solution had been applied the excess moisture was removed with a dry sponge leaving a uniform iodine stain on the skin After the operation iodine solution was applied to the wound site and excess moisture removed. The same procedure was followed at each dressing "

"In this series which comprised 100 consecutive operative cases no postoperative wound infections and no untoward reactions (such as cutaneous burns) followed the use of these two aqueous iodine solutions "

"The aforementioned solutions fulfill the requirements of an ideal skin antiseptic or sterilizing agent as postulated by others "

"An antiseptic which possesses these attributes and in addition is reasonably cheap should be considered an ideal preoperative skin-cleansing agent Aqueous iodine fulfills these requisites and is cheap enough to appeal to the most zealous advocate of economy "

"Experience based on more than 100 consecutive abdominal operations substantiates the efficacy of iodine as an antiseptic "

Disinfection of Hands of Surgical Team It is recognized today that one of the important links in the chain on aseptic surgical technic is the skin of the surgeon s hands as well as those of other members of the surgical team. Sterile rubber gloves are not absolute in their protection, for not only are they porous but slight punctures frequently unnoticed may result in having pathogens enter the open wound Mechanical cleansing aided by vigorous scrubbing as detailed elsewhere in this volume is the initial procedure, being sure that every area of the skin of the hands and arms is reached. The mechanical scrub if vigorous and properly performed removes most of the transients and about one half of the resident flora. A suitable antiseptic is then used as an additional aid to reduce further the numbers of micro-organisms and thus keep the total content down to a minimum

Some workers who do minor surgery or operate only occasionally prefer not to wear gloves and occasionally the protection of rubber gloves may not be pos-

sible In such procedure, after scrubbing the antiseptic is allowed to dry and remain thereon

Between operations where the initial mechanical scrub followed by the use of an antiseptic was thorough, it is not necessary to go through the complete ritual of the preoperative scrub A proper reapplication of the original antiseptic used for disinfecting the skin is usually effective and a sufficient treatment.

The antiseptic used and the technic employed in applying it after scrubbing and rinsing vary among different workers A considerable literature has accumulated on this subject since Price's presentation [32]

Christopher[33] quotes the recommendation by Lilienthal and Ziegler who immerse the perfectly dry finger tips in iodine tincture up to the joint of the terminal phalanx and allow this to dry for five minutes At the end of this time the usual scrubbing process is carried out. Walter[15] states that solutions of "0.5 per cent aqueous iodine are reliable when rubbed into the skin for two minutes An arm soak is convenient, providing room for rubbing the skin while submerged and trapping any solution as it is splashed."

Harrison and Cruickshank[20] in reporting on the importance of glove puncture as a source of surgical infection showed "that dipping the terminal phalanges into iodine immediately before donning the gloves is an excellent method of reducing infectivity of glove interiors during operations The method of applying the iodine is as follows the hands are scrubbed and dried the terminal phalanges are dipped in one per cent iodine in seventy per cent ethyl alcohol the gown is put on the fingers are dipped again and the gloves put over the moist iodine." They state that this "is a valuable method of reducing potential infectiousness in the event of accidental glove puncture"

Price[34] stated that there is nothing commercially available that will add to the antiseptic effect of seventy per cent alcohol save only iodine In the author's laboratory Price's serial scrub technic and modifications thereof were used in an attempt to note the value of iodine solution as an antiseptic for the preoperative preparation of the skin of the operating team In our initial technic,[35] the same procedure as mentioned by Price was used with the result that our findings were almost identical with that reported by him. Modification of the technic using for each of the fourteen one minute scrubs a separate sterile brush and at all times sterile liquid soap (forty per cent) also duplicated the results obtained in the original Price technic. There was a linear decrease in organisms as revealed by the examination of the wash water in each basin after a continuous minute scrub but at no time was there complete sterility A two per cent and later a one per cent aqueous iodine scrub for two minutes was used to supplement the cleansing action of the preoperative scrub interposing this treatment after the eighth one minute soap scrub again after the sixth and also after the third and second one minute soap scrub In all instances the reduction was more marked, so that ultimately the original flora was reduced to an amount never attained by scrubbing with soap alone

Recognizing the fact that in urgent emergencies the time element is frequently a very important factor the technic was modified as follows Two

one minute thorough soap scrubs were used The wash water in each instance was examined and plated The hands and arms were dipped into a one per cent aqueous iodine solution for two minutes, swabbing and at another time scrubbing the entire area at the same time The hands and arms were then dried with sterile paper towels. Sterile rubber surgical gloves were used (without the preliminary application of powder) Thirty minutes later the gloves were removed and a one minute thorough scrub was used A count was made of the wash water The gloves were reapplied and after another thirty minute period, another one minute thorough soap scrub yielded a wash water in which the count was considerably less than two per cent of the original flora This same technic was used but the hands were dusted with sterile "biosorb" before the gloves were put on After the first thirty minute period, the wash water count was less than one per cent of the original flora The speed of action which is attained with the use of the iodine solution was very noticeable.

It is apparent from these findings that for emergency use a few one minute mechanical scrubs with soap and water being sure that every surface of the skin is cleansed thoroughly followed by a two minute soak and swabbing or preferably by a scrub with a two per cent or even a one per cent iodine solution will be as effective for the preoperative preparation of the hands and arms as can be obtained by any other procedure available at present. During emergencies when sterile gloves may not be available or at hand, the iodine solution can be allowed to dry or the excess moisture can be wiped off

Between operations, it is only necessary to reapply the iodine solution preferably by scrubbing or swabbing briskly It is not necessary to repeat the preoperative soap scrub

Disinfection of Contaminated Hands. If hands are unavoidably contaminated by handling infected material, it is necessary that the contamination be thoroughly rinsed off under running water then the hands washed with soap and running warm water It perhaps is best to avoid scrubbing as organisms from the contaminated material may be implanted into deeper areas After drying using a sterile towel, soak or dip for two minutes in a two per cent iodine solution then dry slowly by evaporation or gently remove excess moisture.

Wounds: All wounds are contaminated at the time of injury Infection often results developing in from six to twelve hours and this is the most important factor in delaying wound healing Koch[26] presents five principles to be observed in the care of infected wounds Localization of the infection drainage when the infection is localized sterilization of the infected area covering the raw surface and restoration of function In this chapter we are concerned primarily with the sterilization of the infected area. Iodine (1 5000) is a useful agent in the treatment of infected wounds This is quickly prepared by adding 1 cc of the two per cent free iodine solution (aqueous or tincture) in enough water or isotonic solution of sodium chloride to give a 100 cc volume It can be used in a technic such as the Carrel-Dakin procedure using instillation through tubes or employing gauze packs or dressings saturated in the solution applied directly to the wound and covered. Fresh dressings are applied as necessary Iodinization should be employed until the infection subsides and healthy granulation tissue covers the

surface of the wound In an extensive series of studies in the author's laboratory[31] the following conclusions were reached "Bactericidal efficiency tests of the dilute halogens (1 5000) revealed that free *iodine solutions* displayed more effective antibacterial activity against the test bacteria than did chlorine or bromine at 37 C. or 24 C. (98 6° or 75.2°F) either in the presence or the absence of organic matter *Iodine solutions* of such strength are suggested as being more effective for use as antiseptic washes or for irrigation purposes" Later we[35] reported "Iodine solutions in concentrations of 1 5000 (0 02 per cent) in either distilled water or isotonic solution of sodium chloride or either of the two diluents each containing five per cent citrated human plasma, displayed more effective antibacterial activity against several test bacteria either at 24°C. or 37°C as compared to solutions of chlorine (1 5000) or free bromine (1 5000 w/v) The test bacteria used were broth cultures of *Staphylococcus aureus Salmonella (Eberthella) typhosa Pseudomonas aeruginosa Escherichia coli* vegetative forms of *Bacillus megatherium* vegetative forms of *Bacillus mesentericus* and vegetative forms of *Bacillus subtilis*"

"Weak iodine solutions (1 5000) displayed findings as above in pH ranges from 2.2 to 8 0 Identical concentrations of free bromine and chlorine under similar tests were ineffective"

"Solutions of free iodine 1 5000 (0 02 per cent) for use as an antiseptic wash or for irrigations were readily prepared by diluting 1 cc. of two per cent iodine solution (N.F VIII) and/or two per cent iodine tincture (U.S P.XIII) to 100 cc. with distilled water or isotonic solution of sodium chloride"

Use of 1 1000 Iodine Solution Where a stronger solution is needed as an antiseptic wash, a 1 1000 iodine solution can be used. Such strength can be prepared by diluting the two per cent preparation adding 1 cc. of the latter and 19 cc. of diluent. Such a solution can be used conveniently in first aid treatment anywhere, anytime when an antiseptic wash or rinse is required It can be used for irrigation purposes to replace the 1 500 concentration. Where friction for a few minutes cannot be used when employing the two per cent solution, the latter can be replaced using on the area wet dressings of a 1 1000 aqueous iodine solution for a period of thirty minutes

Disinfection of Skin Before Parenteral Administration Removal of Body Fluids, Cutting Skin Grafts, Obtaining Blood for Blood Bank, etc. In a memorandum drawn up by the Public Health Laboratory Service and the London Sector Pathologists Committee,[39] avoidable meningitis is considered from the standpoint of "the direct inoculation of micro-organisms into the spinal canal" as might occur during intrathecal injections of medicaments or the withdrawal of spinal fluid. Among the various recommendations presented are found the following "thorough, not perfunctory swabbing with tincture of iodine or seventy to ninety per cent alcohol" of the skin of the patient. "This will leave little risk of contamination of the needle by the patient's skin" When removing medicaments from a rubber-capped bottle, "the cap should be thoroughly swabbed with seventy per cent alcohol or tincture of iodine."

Walter[16] cites the experience of the American Red Cross Blood Donor Service where U.S.P iodine tincture is used. The fact that "60 658 consecutive pints

of blood were taken without a single contaminated bottle" speaks well for the efficiency of this antiseptic

Braude et al[40] in discussing bacterial contaminants in transfused blood includes the technics used to obtain blood from donors at the University of Michigan and states that the skin is "cleansed with seventy per cent alcohol before treatment with tincture of iodine"

Huss *et al*[41] describing their method for obtaining bone marrow by vertebral spinous process puncture mention "A large square of the back surrounding *the designated spinous process is iodinized*" If the operator is not aseptically gloved his "fingers are iodinized."

Webster[42] in describing the method used when cutting a skin graft, indicates that the donor site selected is cleansed and painted "with tincture of iodine (3½ per cent)"

Many references can be cited in addition to the above indicating that rigid aseptic precautions are required and that *iodine tincture is the ideal, safe antiseptic* for the disinfection of the skin area prior to the removal of blood, spinal fluid and transudates such as pleural, peritoneal, and synovial effusions The same rigid aseptic precautions and the use of iodine tincture should be employed when administering medicaments parenterally especially intravenously intrathecally and intramuscularly Injections given subcutaneously or intracutaneously or tests performed by either route are frequently administered only after wiping the skin with alcohol This procedure as usually carried out though satisfactory in many instances is not as safe as when using iodine tincture or iodine solution

TECHNIC After cleansing the skin swab iodine tincture or iodine solution on the skin area This may or may not be removed after one or two minutes, as desired, by wiping with alcohol The iodine, if convenient may be left on until after the removal of the fluid or the injection is given and then wiped off with alcohol or sterile sodium thiosulfate solution if desired

Disinfection of Knife Blades, Catheters, Instruments, Plastic Tubes, and Other Plastic Items, Rubber Tubing Rubber Gloves, and Other Rubber or Synthetic Rubber Goods, Brushes, Ampuls, and Vials, etc.: Because of its "rapid and high bactericidal efficiency" iodine has been recommended as an "emergency sterilizing agent" for surgical instruments Walter[15] indicates that "steam will affect many bristles, especially animal bristles. Brushes can be disinfected and stored in an 0.5 per cent aqueous solution of iodine or even 1 400" The author has recommended the use of an 0.5 per cent (or even one per cent) free iodine solution for sponges and brushes to be kept saturated therein for use as needed

Similar statements can be quoted from many other references where mention is made of the use of chemical disinfection of instruments and other equipment. Heat may affect or destroy the latter or the fact that in an emergency and especially when large quantities of material are needed or heating facilities are not available, one can only resort to the use of chemical disinfection A solution of a suitable disinfectant can be used also as a storage liquid for many items Iodine solutions in strengths from 0.5 per cent to 2 per cent of free iodine are very useful and effective for these purposes In the case of ampuls and multiple dose vials where the exterior of the latter is wiped with an antiseptic prior to the removal of the contents it may be desirable when using large quan

tities of the agent being administered to submerge the containers in the iodine solution Leaks and cracks are frequently detected, inasmuch as the contents are colored by the bactericidal agent.

In the terminal disinfection of instruments and textiles after operation these can be placed in a bucket containing an iodine solution until they are ready to be cleansed and sterilized.

Disinfection of Clinical Thermometers, Hypodermic Needles, etc.. The need of sterilizing large numbers of needles for the parenteral administration of various mixtures is apparent, especially during violent catastrophes. Chemical disinfection may be the only available procedure

Large numbers of thermometers may require sterilization or the quick disinfection of the available supply to be ready for immediate use may be necessary In both instances the use of a suitable antiseptic may suffice

In the author's laboratory [12] "the antibacterial efficiency of various commonly used iodine solutions and different alcohols as agents for the cold disinfection of clinical thermometers was determined The compounds used were iodine solution (two per cent) N F IX, iodine tincture (two per cent) U.S P XIV ethyl alcohol (ninety-five per cent) ethyl alcohol (seventy per cent by weight) ethyl alcohol (fifty per cent by volume) isopropyl alcohol (seventy per cent by volume) and isopropyl alcohol (fifty per cent by volume)"

"Graduated clinical thermometers which were cut into sections two inches long and sealed at both ends were used. The sterile sections were treated with cultures of test bacteria. The test organisms used in the study were *Diplococcus pneumoniae Staphylococcus aureus Streptococcus hemolyticus Streptococcus fecalis* and *Escherichia coli* The test organisms were thoroughly dried onto the thermometer sections" "The treated thermometer sections remained in the disinfectant solution at 20°C (68°F) for the designated time period, rinsed for ten seconds in sterile distilled water and transferred to tubes containing media. Thermometer sections treated with iodine solutions were transferred after treatment to media containing one per cent thiosulfate The transplant tubes were incubated for forty-eight hours at 37°C (98 6 F) and the cultures were examined for observation of growth."

"In order to determine the effect of large quantities of organic matter upon the disinfectants under test, citrated human blood plasma in concentrations of twenty-five and fifty per cent, was added to the initial culture media tubes containing a twenty four hour growth of *S aureus*

"1 In tests conducted against *S hemolyticus* the iodine (tincture two per cent and solution two per cent) and alcohols with the exception of ethyl alcohol ninety five per cent, killed the test organisms within twenty seconds"

"2 Iodine tincture two per cent (U.S.P.XIV) and iodine solution two per cent (N.F IX) killed *S fecalis* within 100 seconds while the alcohol disinfectants did not kill within 120 seconds."

"3 The iodine preparations killed *E coli* more quickly than did the alcohols, while ethyl alcohol ninety-five per cent did not kill within 120 seconds"

"4 Iodine tincture (two per cent) killed *S aureus* within eighty seconds while iodine solution two per cent required 120 seconds to kill. Ethyl alcohol ninety-five per cent was ineffective

against *S aureus* within ten minutes The most efficient alcohol was isopropyl seventy per cent, which killed *S aureus* within four minutes while the other alcohol disinfectants killed within ten minutes "

"5 Tests conducted with a fifty per cent plasma–*S aureus* culture mixture revealed that iodine solution two per cent killed *S aureus* within five minutes The other test disinfectants did not kill the test organism within ten minutes "

"6 In similar tests using a twenty five per cent plasma–*S aureus* culture mixture iodine solution (two per cent) killed *S aureus* within three minutes while the other test disinfectants were ineffective within a ten minute test period "

"7 Iodine tincture U.S P or iodine solution N F widely used antiseptics which are readily available everywhere were found to be more effective than either ethyl alcohol or isopropyl alcohol for the quick disinfection of clinical thermometers which were heavily infected with many of the commonly found bacteria "

Catgut and Other Surgical Suture Materials. In the case of surgical gut the nonboilable or hydrated type must not be heated and is disinfected by a suitable antiseptic solution The hydrolysis caused by the heat will destroy the gut. In case of the boilable or anhydrous type or other suture materials which can withstand steam sterilization the latter procedure may not be available or not adequate for the sterilization of enormous quantities as may be needed in sudden violent catastrophes. Also the exterior of the unopened tubes must be disinfected before use The tubing fluids used today by some manufacturers contain iodine or iodine compounds as the antibacterial agent

With the wide use of all kinds of textile and synthetic fibers it is not possible to make a general statement that in emergencies all of them can be disinfected In occasional instances it is possible that the agent used may affect the tensile strength. Such information can only be obtained after trying the technic advocated.

The very nature of surgical sutures accounts for the fact that they are contaminated and is responsible for their contamination and frequently makes it difficult to effect positive sterilization Also the use for which they are employed makes it imperative they be properly sterilized. Since 1902 catgut for surgical sutures has been reported as having been "sterilized with iodine " Christensen[14] in discussing catgut sterilization recommends the use of a one per cent iodine solution He indicates that even after four hours exposure there was but little effect upon the tensile strength, and the treated material was "absorbed exactly as catgut manufactured in other ways "

Disinfection of Water In "Advances in Military Medicine "[15] water disinfection especially in the field, is detailed Iodine 8 ppm., for a contact time of ten minutes was found to kill water borne pathogens including amebic cysts, the cercariae of the schistosomes and the leptospirae of infectious jaundice In this dosage "high-level intake of iodine treated water by men undergoing physical exertion under simulated tropical conditions produced no noticeable chemical disturbances, metabolic changes or interference with work performance " For canteen use a tablet was made available containing tetraglycine hydroperiodide One tablet is used for each canteen for a ten minute period Two tablets for ten minutes are required for

highly colored waters. For cold water the time period is extended to twenty minutes

Previously the United States Public Health Service[19] recommended the disinfection of drinking water by the addition of the seven per cent tincture of iodine in an amount of approximately equivalent to one drop of the latter per liter (quart) of water and a time period of from ten to thirty minutes depending upon the clarity This gives a weaker solution of free iodine than the above mentioned 8 ppm. Six minims of the two per cent iodine solution or tincture per quart yields approximately 8 ppm.

In times of emergencies when drinking water is at a premium, the above treatment will assure a safe potable water for human consumption Where a sterile water is needed and heating methods are not available the free iodine content can be increased.

Sanitizing Eating and Drinking Utensils. During emergencies and violent catastrophes, it is of even greater importance to treat eating and drinking utensils properly especially if they are used by the sick. Iodine will serve as a useful *sanitizing* agent for such purpose In a detailed study conducted in our laboratory we[17] found that "dishes, cups, glassware, knives, forks and spoons which had been scraped and given a preliminary ten second rinse in water (between 130 and 170 F [54 6 and 76 7 C.]) were sanitized by a one second immersion in iodine solutions (100 ppm and 200 ppm.) "

"The dilutions of free iodine tested *ranged* from 200 ppm to 0.5 ppm Solutions containing free iodine were prepared from iodine solution (two per cent) N F IX The 200 ppm free iodine dilution was prepared by placing 1 ml of the two per cent iodine solution in 99 ml. of distilled water " We that a concentration of 200 ppm. ' greater safety throughout the eight working day A teaspoonful of solution (two per cent) (N.F.D iodine tincture (two per cent) (U XIV) to a pint of water will g solution of approximately this str Solutions of this concentration found to have no adverse effect any kind of utensils after rep *treatments* "

"It is possible to prepare quickl iodine solutions containing 200 for use everywhere including and cially when sanitization is to be pra for eating utensils used by the sicl

Solutions of free iodine of suf strength to be used safely in food t sanitization were observed to rar color from yellow to deep amber solutions too dilute to inhibit the g of the test organism were very pal low This change in color can be to advantage in judging whether tions of free iodine still possess sanitizing strength

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GILBERT B AYRES PH.D

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Sutures in Emergencies

EVER since the rediscovery of the ligature by Ambroise Paré, one of the principal uses of ligatures and sutures has been in emergencies, particularly those resulting from war-caused injuries The large use of sutures for elective surgery is a relatively recent development but even in these days of high peacetime consumption, the demand during times of armed conflict far exceeds normal civilian requirements

Although absorbable sutures and ligatures were known and used long before Lister s time, it was he who first brought catgut into its own as the predominant suture. Contaminated wounds of the pre Lister era digested the catgut so rapidly that hemorrhage or dehiscence, and often both, were the inevitable consequence of ligating and suturing with cat gut. Nonabsorbable sutures particularly silk and linen, were widely used, for although these were not sterile and harbored contamination, they at least resisted bacterial and leukocytic enzymes so that the patient did not die of hemorrhage even if he later succumbed to septicemia or gangrene Lister's treatment of catgut to resist digestion by chromicizing together with better surgical technics and antiseptics made cat gut the suture of choice Until Halsted's work became known, silk was little used in general surgery Today with further advances including better aseptic technics, chemotherapeutic agents, and antibiotics, the surgeon often prefers to use nonabsorbable sutures, such as silk and cotton, and wounds formerly left open may now be closed with impunity

In an extreme emergency such as an all out war where high explosive and conventional and atomic bombs are used against large centers of population, the nature and extent of the injuries with which the civilian medical profession will be confronted, will be beyond imagination and unlike anything ever encountered by the average practitioner unless he has had wartime experience Normal facilities will be disrupted and usual supplies often unavailable so that the doctor called in to handle such cases may be forced to use whatever can be obtained locally at the time. This chapter will be largely devoted to describing the various materials which can serve as sutures and ligatures

1 Absorbable Sutures. CATGUT OR SURGICAL GUT Both boilable and nonboilable varieties are used, although many hospitals and surgeons have had little experience with boilable gut. The Armed Forces use substantial quantities of boilable catgut as it can be handled more easily under field conditions In

an emergency boilable gut may be all that is available Suture tubes exteriors of boilable catgut may be sterilized by boiling or autoclaving or submersion in a chemical antiseptic which is compulsory for nonboilable sutures While non boilable sutures may be used immediately upon removal from the tube boilable gut must be soaked in sterile water physiological saline or seventy per cent ethyl alcohol to restore the flexibility lost in dehydration and sterilization The approximate time of soaking will vary depending on the size and type as shown in the following table

preferred a sterile towel saturated with sterile water physiological saline or seventy per cent alcohol may be used, the gut being placed between the folds of such a towel. Evaporation of the liquid may be prevented by enveloping the towel in a rubber dam or plastic film The gut should be exposed for not over thirty minutes if the towel be saturated with water or sterile saline and for over one hour with seventy per cent alcohol Temperature conditions are the same as for immersing directly in the liquid

All suture tube exteriors boilable or nonboilable absorbable or nonabsorbable may be sterilized chemically Non boilable surgical gut must never be heated or stored above 122 F (50 C) and preferably never above body temperature so it is essential to sterilize the outside of tubes of such sutures with a germicidal solution Such germicides are preferably alcoholic (about seventy per cent) as tubes will submerge in these solutions and the alcohol facilitates penetration through any dirt or fatty material Normally it is unnecessary to scrub suture tubes prior to sterilization The diluted alcohol must be fortified with a suitable bactericidal agent, preferably one that is a good sporicide One of the best and one com

TABLE I

RESTORATION OF FLEXIBILITY OF BOILABLE SURGICAL GUT

Size	Immersion Time			
	Plain		Chromic	
	Water or Saline	70% Alcohol	Water or Saline	70% Alcohol
6-0 to 4-0	5 sec.	1 min	10 sec.	2 min.
000 00	10	2	15	3
0	20	2.5	25	3.5
1 2 3	30	3	40	4

Note that the immersion time in seventy per cent alcohol is far greater than that in water or saline Catgut sutures should not be soaked for longer periods as the strength of the suture will be impaired by so doing. However they may be kept in a sterile towel saturated with seventy per cent alcohol for ten minutes for small size plain gut sutures to over an hour for larger diameter chromic

The temperature of the immersion fluid should be room temperature or warmer but not over body temperature (98 6 F., 37 C) The times of immersion should not be exceeded or the strength of the gut will be reduced If

monly available is formaldehyde A satisfactory solution may be made as follows

Ethanol, 95% or isopropanol, 99%	700 cc.
Solution formaldehyde, 37%	25 cc.
Distilled water q.s. ad	1000 cc.

The resulting alcohol concentration will be approximately seventy per cent and *formaldehyde one per cent.* All ingredients should be U.S.P or purer If metallic objects are apt to come in contact with the solution, 1 0 gram each of sodium bicarbonate and sodium nitrite should be added as corrosion inhibitors. A suitable dye such as gentian violet, eosine sodium fluorescein etc. may be used to color the germicide if desired. A concentration of 0 001 per cent or less is usually sufficient

The above germicide can be depended upon to destroy bacterial spores such as those of *B subtilis Cl tetani* or *Cl sporogenes* within eight hours at room temperature The solution will retain its potency for prolonged periods and need only be replaced when it becomes discolored or when tubes fail to submerge Losses should be made up by adding sufficient fresh solution. Sutures themselves should never be sterilized in this solution since the formaldehyde is irritating to the tissues, and in the case of catgut, loss of strength and a change of its absorption characteristics will ensue Unfortunately no satisfactory method for the resterilization of gut exists so that once it becomes contaminated, it must be discarded.

Catgut is a purified collagen of mammalian origin usually ovine, and is commonly derived from intestinal submucosa or peritoneum. Another absorbable suture is kangaroo tendon derived from the tail of kangaroos and wallabies. Because of their short length (usually less than 0.5 meter [20 inches]) and large size they have limited use and are employed mainly in orthopedic surgery and herniorrhaphies

Absorbable ribbons of collagen have been found particularly valuable in the repair of lacerations of the liver* which type of wound would not be uncommon under emergency conditions Likewise for the repair of other soft tissue where broad support is needed ribbon gut (Davis & Geck, Inc) can be invaluable to the surgeon confronted with such problems

2. **Nonabsorbable Sutures.** There are several nonabsorbable materials which can serve as satisfactory sutures and ligatures in an emergency In addition to the commonly used materials such as silk, nylon, cotton linen, and metallic wire there are several less known threads which can be used when none of the above is available There are ramie which has characteristics like linen or cotton the polyacrylic fibers such as orlon ® X 51 ® and acrilan,® the polyesters terylene or dacron® and rayon, if of the regenerated cellulose type like fortisan® Other rayons should be avoided as they may produce undesirable tissue reactions and often have low wet strength All except ramie are synthetic fibers with continuous filaments and therefore resemble silk and nylon. With the possible exception of the polyesters these materials are inferior to silk and nylon in tensile strength, particularly at the knot, but if this is borne in mind, perfectly satisfactory surgical results can be obtained. Each of the various materials will be discussed briefly individually

(a) SILK Silk is available in two forms, twisted and braided. Practically all surgical silk sold and used today is

* Silvis, R. S., Liver Suture, U S. Armed Forces M J 2 1205 (Aug.) 1951

braided because of its better handling properties Most surgical silk is treated to render it noncapillary or serum proof This is a most desirable characteristic as it prevents the strand from acting like a wick transferring infection from one site to another When silk is used as a skin suture this treatment greatly facilitates its removal. In the past, surgeons have often waxed their silk with paraffin or white beeswax to render the strand non capillary This may be done in an emer gency if no treated silk is available This treatment will not, however increase the strength of the strand but will give it better handling properties and eliminate fraying.

Unless supplied by a reliable suture manufacturer the surgeon should beware of silk dyed colors other than black which is usually logwood (hematoxylin or so-called "iron-dye") White silk is nor mally safe but even here dyes may be em ployed to mask the normally yellow color of silk.

Silk is best sterilized by autoclaving at 6 8 kg (15 pounds) steam pressure (250 F 121 C) for thirty minutes High grade surgical silk can normally be safely resterilized Care should be exer cised not to sterilize silk under tension or in contact with any substance other than pure water Boiling for thirty minutes may also be used by this method but cannot be depended upon if resistant spores are present nor can it be used at elevations much above sea level. Excessively dry silk may lose strength on sterilization by auto-claving so it is usually desirable to moisten the strand first.

(b) COTTON Cotton (twisted) came into prominence as a suture during World War II when silk supplies were cut off by Japan and has been increasing in popu larity It is not as strong as silk but has the unique property of increasing in strength when wet with water or body fluids Cotton is a staple fiber i.e it is composed of a multiplicity of short fibers rather than long, continuous filaments like silk. Because of this increase in strength when wet it is usually undesir able to treat it to render it noncapillary As with silk, the surgeon should avoid colored cotton unless supplied by a reli able suture manufacturer since some dye stuffs may evoke unfavorable tissue reac tions Mercerized cotton is stronger and is free from natural waxes which have produced unfavorable tissue reactions, so that cotton treated in this way is best. Long staple cotton, particularly Egyptian Karnak produces the strongest thread.

When cotton sutures are sterilized by autoclaving care should be taken to wet or hydrate the cotton first Otherwise the cotton may "burn" or "char" from the heat of combination of the steam and the dry strand with a resulting loss in tensile strength. Like silk, cotton may be resteril ized if properly hydrated each time Sterilization conditions are similar to those of silk.

(c) NYLON Nylon is commonly fur nished in two forms monofilament and multifilament, usually braided Twisted nylon thread while strong and readily available has never enjoyed any popular ity as a suture because of its inferior physical properties In an emergency it could be used with excellent results but the surgeon should avoid colored thread because of the uncertainty as to whether a suitable dye was used Monofilament and braided nylon is available only through suture manufacturers and dis tributors and when dyed can be relied upon Nylon is a generic name for vari ous polyhexamethylene adipamide pol ymers often designated as type 66 Perlon

and supramid are widely used in Europe to designate nylon type polymers some of which are caprolactam derivatives In general they make suitable sutures but a complete description of the various types is beyond the scope of this chapter Sterilization is similar to silk.

(d) METALLIC WIRE Many surgeons consider metallic wire the acme in sutures because of its great strength and the almost complete absence of tissue reaction of suitable metals The metals enjoying the greatest popularity today are stainless steel and tantalum In an emergency the surgeon will have to beware of substitute materials which may not be suitable and which may result in serious harm to the patient. Alloys such as monel should be avoided and especially copper nickel, or iron wire The precious metals platinum, gold, and silver can be safely used, although silver is not without some tissue reaction. Other lesser known metals like titanium and zirconium make suitable sutures although less desirable than *stainless steel or tantalum*. The surgeon should question any plated or coated wires since the surface substance may be abraded or perforated exposing the core. True stainless steel wire is nonmagnetic, will not corrode in boiling water nor plate out copper from an acid copper sulfate solution

Wire is available as monostrand or multistrand, usually twisted. The latter material is the more flexible and easily handled. Soft, annealed wire while lower in tensile strength is relatively free of springiness and should be obtained whenever possible.

Wire can be sterilized by autoclaving or boiling or even by dry heat (320 F., 160 C for one hour) Wire for sutures should never be sterilized by heating in flame as it may be changed in its physical characteristics or oxidized so as to render it unsuitable for use Wire can normally be sterilized *ad infinitum* by autoclaving or boiling.

(e) LINEN Linen like cotton is a staple fiber and has similar properties. While still popular abroad it is now used only to a minor extent in this country Linen for surgical purposes is often coated with celluloid (Pagenstecher's thread) to improve its physical properties particularly to lay down the "whiskers"

The celluloid treatment does not interfere appreciably with the uptake of moisture which results in an increase in tensile strength. Sterilization of linen is similar to silk. Most linen thread is natural color or unbleached. Some black surgical linen thread is produced and material from a reliable suture manufacturer is dependable Other dyed linen threads should be avoided.

(f) OTHER NONABSORBABLE SUTURES. (1) *Silkworm Gut* This is monofilament silk and while formerly widely used in plastic surgery and for skin suturing, it is encountered less frequently today It can be sterilized like silk.

(2) *Horsehair* Once used in plastic surgery it is rarely *employed today Any* hair product must be thoroughly cleaned with soap and water and well rinsed in alcohol and water prior to sterilization, which is similar to silk.

(3) *Dermal*. Although any skin suture may be classified as a dermal suture this term usually *refers to a silk* or nylon thread (a multistrand with a low twist) *coated with hardened* gelatin or other suitable material. This reduces knot slippage and facilitates removal after healing is completed Sterilization is like silk.

(4) *Terylene or Dacron*. These fibers are polyesters of ethylene glycol and

terephthalic acid and possess excellent tensile strength Because terylene is difficult to dye colored strands, unless from a reliable source, should be regarded with suspicion Sterilization is similar to silk.

(5) *Polyacrylate Fibers.* Orlon (Du Pont) X 51 (American Cyanamid) and acrilan (Monsanto) are typical of this group These fibers make satisfactory sutures but have lower strength particularly at the knot than silk nylon, or terylene Dyed strands should be questioned unless of dependable origin Sterilization is like silk.

(6) *Rayon* There are many kinds of rayon, not all of which are suitable as sutures Many rayons have poor wet strength and some evoke undesirable tissue reaction Rayons of the regenerated cellulose type which are essentially pure cellulose are usually safe to use Fortisan (Celanese Corp) is one of the best types but while it has excellent straight pull tensile strength, its knot strength is poor and care must be used in tying knots. Square knots will usually break less frequently than surgeons Sterilization is the same as silk.

(7) *Ramie* Ramie is similar to linen but is longer staple and has somewhat greater tensile strength. Natural or undyed material is safe to use and may be sterilized like silk

(8) *Miscellaneous* There are other fibers both natural and synthetic which may serve as satisfactory nonabsorbable sutures but sufficient data has not been accumulated on them so that their use is dubious or even hazardous Glass fibers have not worked out well because of mechanical irritation and most other synthetics have too low tensile strength to be practical Polyethylene (unplasticized) while substantially inert in the tissues, is of too low tensile strength to serve as a suture Various regenerated proteins derived from casein zein, soy bean and peanut proteins while absorbable lack sufficient tensile strength to be of any use as sutures

Comparison of Various Suture Materials

The following table the basic size data for which are taken from the United States Pharmacopeia XIV Revision, will give the size comparison of common suture materials.

Cotton sutures may vary considerably from manufacturer to manufacturer as the numerical designations are based on the yarn number which is the quantity of 840 yard hanks in the pound. These yarns are plied and corded together to form a thread. Surgical cotton is specially selected for proper diameter and maximum tensile strength and will be much more dependable than commercial thread

The standards for wire based on the B&S gauge are very precise and wire normally never varies more than $\pm 0.0002''$ from the standard diameter for a given size. Where more than one B&S number is equivalent to a suture size maximum strength can be obtained by using the smallest numerically B&S number

Commercial threads of other substances such as silk, nylon, linen and the other natural and synthetic fibers mentioned previously have many different literal and numerical designations which are too numerous to go into here The commonest are given in Table II If a surgeon is accustomed to using a given suture size for any particular application he should select by visual comparison, a proper thread of similar diameter Because of the difficulty of estimating diameter variations of the order of one to three thousandths inches by eye the surgeon should also pick out strands larger and smaller for trial

TABLE II

COMPARISON OF SUTURES

USP Suture Size Designation	Diameter in Inches		Minimum Tensile Strength in Pounds		U.S.P Suture Size Designation	Commercial Cot Sizes	American Standard Wire (Brown and Sharpe) Gauge	Silk and Cotton Thread Sizes[4]	[illegible]
	Non-Boilable Surgical Gut[1]	Boilable Gut and Non-Absorbable Sutures	Straight Pull[2]	Over a Surgeon's Knot[3]					
7-0	0.0010–0.0025	0.001–0.002	0.25	0.125	7–0				
6–0	0.0025–0.0045	0.002–0.004	0.5	0.25	6–0		38–40	OOOOO	
5–0	0.0045–0.0070	0.004–0.006	1.0	0.5	5–0	80–100	35–37	OOO	
4–0	0.0070–0.0095	0.006–0.008	2.0	1.0	4–0	40–80	32–34	A	
000	0.0095–0.0125	0.008–0.010	3.0	2.0	000	30–40	30–31	B	6.3
00	0.0125–0.0160	0.010–0.013	5.0	3.0	00	16–30	28–29	D	35/3
0	0.0160–0.0195	0.013–0.016	7.0	5.0	0	12–16	26–27	E	[illegible]
1	0.0195–0.0230	0.016–0.019	10.0	7.0	1	10–12	25	FF	25/3
2	0.0230–0.0265	0.019–0.022	13.0	9.0	2	4–10	24		[illegible]
3	0.0265–0.0300	0.022–0.025	16.0	11.0	3		23		
4	0.0300–0.0340	0.025–0.028	20.0	13.0	4		22		
5	0.0340–0.0385	0.028–0.032	25.0	17.0	5		20–21		
6	0.0385–0.0435	0.032–0.036	30.0	21.0	6		19		
7	0.0435–0.0490	0.036–0.040	35.0	25.0	7		18		

[1] Nonboilable gut swells in the alcoholic (usually ethyl or isopropyl) tubing fluid to these diameters
[2] Sterilized values for nonabsorbable sutures are eighty per cent of these figures.
[3] Applicable only to surgical gut.
[4] These may be subject to considerable variation between manufacturers. Materials such as kangaroo tendons, ribbon gut silkworm gut and horsehair are not U.S.P

The size which gives the best all-around performance should then be selected for use. As a rule it is well to choose an unknown thread slightly heavier than that with which the surgeon is familiar until experience has been gained. The knot strength is the Achilles heel with any suture since it is at the knot that almost all breakage occurs. Some fibers like fortisan, have relatively poor knot strength so that this must be taken into consideration.

Size Selection Under emergency conditions the surgeon may not always be able to get his preferred material or size. In addition, many medical practitioners will be called upon to cope with situations they have never encountered and for which little information exists as to the best procedure to follow. There will be a tendency to use sutures much larger than otherwise in order to err on the safe side. The surgeon should curb this proneness since big sizes introduce excessive amounts of foreign material to interfere with normal healing. Experience gained during and after World War II has shown that the best surgical technics which include the use of minimal diameter sutures, must be applied to the emergency surgery of war wounds in order to achieve the high survival rates obtained. Small diameter sutures properly used, save time, so essential in emergencies, and contribute to gentler handling of the tissues. It should be remembered that the amount of foreign material introduced [illegible]

square of the diameter Thus a given length of a size 000 suture having a diameter of 0 009" will contain only one-fourth the material of a size 1 strand with a diameter of 0 018" A size 000 suture is usually stronger than any tissue including fascia A suture stronger than tissues in which it is placed will only cut through if excessive strain is placed on it. Interrupted sutures are obviously stronger and are less prone to disrupt than continuous but the succession of knots resulting from the placement of *buried interrupted sutures leaves behind* more foreign matter and in the case of absorbable sutures the knots are more refractory to digestion Double and triple knots are less apt to slip but the mass of foreign material left behind may *be extruded later*

Although plain gut (type A) produces more tissue reaction than chromic, *it is absorbed more rapidly and should* always be used to suture tissues which heal rapidly like peritoneum or which *absorb sutures slowly like fat. Although* the three types of chromic, mild (type B) medium (type C) and extra (type D) are designed to provide a range of absorption, over ninety five per cent of all chromic gut sutures employed are medium Most of the mild chromic is used in ophthalmic surgery while the extra is utilized by the obstetrician and gynecologist. Under emergency conditions all three types can be used interchangeably provided good surgical technics are followed. Chromic gut of a given size will be five to ten per cent stronger than plain although plain is slightly more flexible.

In closing abdominal wounds tension or stay sutures can often be used to advantage Monofilament nylon (sizes 0 and 1) wire (size 000) and braided silk or nylon (sizes 0 and 1) are most suitable and will provide added support to devitalized tissues However sutur*ing tissues under tension will often re*sult in complications, gaping between sutures stretching and in some cases actually pulling out of the sutures with resulting necrosis and dehiscence Good surgical technic is just as essential in *emergencies as under the optimum* peacetime conditions

In conclusion, the surgeon or physi*cian has a wide variety of dependable* suture materials which can come to his aid during an emergency Many gov*ernmental agencies federal,* state and municipal are stockpiling reserves of sutures and needles so as to have supplies available *if disaster strikes*. Even though these stocks may be destroyed or consumed, other fibers can serve adequately *so that the physician* can be confident that he can carry out his work effectively and in keeping with the highest tradi*tions of his profession*

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